FIELD DISTRIBUTION AND ENTRAINMENT OF FISH LARVAE AND EGGS AT THE DONALD C. COOK NUCLEAR POWER PLANT, SOUTHEASTERN LAKE MICHIGAN, 1980-1982

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INTRODUCTION

PURPOSE OF THE STUDY

Mortality induced by entrainment of fish eggs and larvae and impingement of juvenile and adult fishes may be the most important biological influence power-generating plants exert on nearshore fish populations. These impacts clearly overshadow thermal discharge effects. Entrainment could significantly affect local Lake Michigan fishes by reducing the reproductive potential of important forage or gamefish populations. Because of this potential impact of the Donald C. Cook Nuclear Power Plant, we have intensively documented species, sizes, and numbers of fish larvae and eggs that were entrained at the plant from 1975 to 1982. In this report we will attempt to identify, interpret, and predict the effects of fish larva and egg entrainment on southeastern Lake Michigan's nearshore fish populations. Data in this report will cover the period 1980-1982. See Bimber et al. (1984) for 1973-1979 data summaries.

Schubel and Marcy (1978) defined two forms of entrainment - intake or pump entrainment and plume entrainment. Intake entrainment is the capture and inclusion of organisms, in our case fish eggs and larvae, into water used for condenser cooling. Plume entrainment is the attraction or mixing of adults and larvae from lake water near the discharge into the thermal plume. We did not sample plume-entrained eggs or larvae because of difficulties encountered in adequately and safely collecting organisms from this area. Effects of plume entrainment on adults are discussed in the adult and juvenile fish report prepared by the Great Lakes Research Division as part of the Cook Plant study (Tesar et al. 1985, Jude and Tesar 1985). In this report, entrainment, unless otherwise noted, will refer specifically to intake entrainment.

To more clearly define the effects of entrainment on southeastern Lake Michigan's fish community, we must (in addition to documenting species, sizes, and numbers entrained) relate those losses to the distribution, abundance, and life cycles of fishes near the Cook Plant and assess the associated effects on individual fish populations and community structure. The ultimate effect of entrainment losses will be dictated by the system's "resiliency", i.e., environmental stability, productivity, population compensation, and the ecological and economic importance of individual species. To attain these goals, we conducted field studies to identify the species, sizes, numbers, spatial distribution, and seasonal occurrence of adult fish, fish larvae, and eggs near the Cook Plant.

Most fishes in our study areas have similar seasonal movement patterns, usually related to spawning activity. They move inshore for spawning in early spring or summer where they remain until moving into deeper water in fall. Salmon, trout, and coregonines differ from this basic pattern and are usually present in spring, fall, and during upwellings. Entrainment losses generally peak during and shortly following spawning and are sporadic thereafter. Mortality of eggs and larvae during entrainment is the result of a combination of mechanical, thermal, and chemical stresses.

Field studies were used to identify the species, sizes, numbers, spatial distribution, and season of occurrence of fish larvae and eggs near the Cook Plant. We compared field and entrainment results to determine the amount of agreement between them, elucidate the biological causes for disagreement, and evaluate the adequacy of the two sampling programs. Lastly, we suggested how the location, design, and seasonal schedule of operation of water intakes on southeastern Lake Michigan could affect the rate of entrainment of eggs and larvae of inshore fishes. Our findings and interpretations are the subject of this report.

STUDY AREA

The Donald C. Cook Nuclear Power Plant occupies part of a 263-ha site on the southeast shore of Lake Michigan that includes approximately 1,326 m of dunes shoreline. The plant is located about 3 km northeast of Bridgman, Michigan, in Lake Township, Berrien County (Fig. 1).

With both reactors on line, the Cook Plant has a generating capacity of 2,200 megawatts of electricity. The plant utilizes a once-through cooling system capable of a maximum service water flow rate of 104 m^3/s to dissipate an estimated heat rejection rate of 3.9 X 10^9 Kg-calorie/h (AEC 1973). Condenser design modifications account for differential flow rates for Unit 1 (45 m^3/s) and Unit 2 (59 m^3/s). Temperature increases (Δ T) over ambient lake water temperatures are 12.1 C° (Unit 1) and 9.3 C° (Unit 2) at maximum generating capacity (AEC 1973). Decreased flow rates and slightly increased Δ Ts occur in winter when heated water is pumped back through the intake structures via one of the three intake pipes to reduce ice formation.

Water for both condenser units is drawn from Lake Michigan through three intake structures 686 m offshore in 7.3 m of water (mean lake level - 176.5 m above sea level). Intake structures rest on a concrete and riprap base structure approximately 2 m

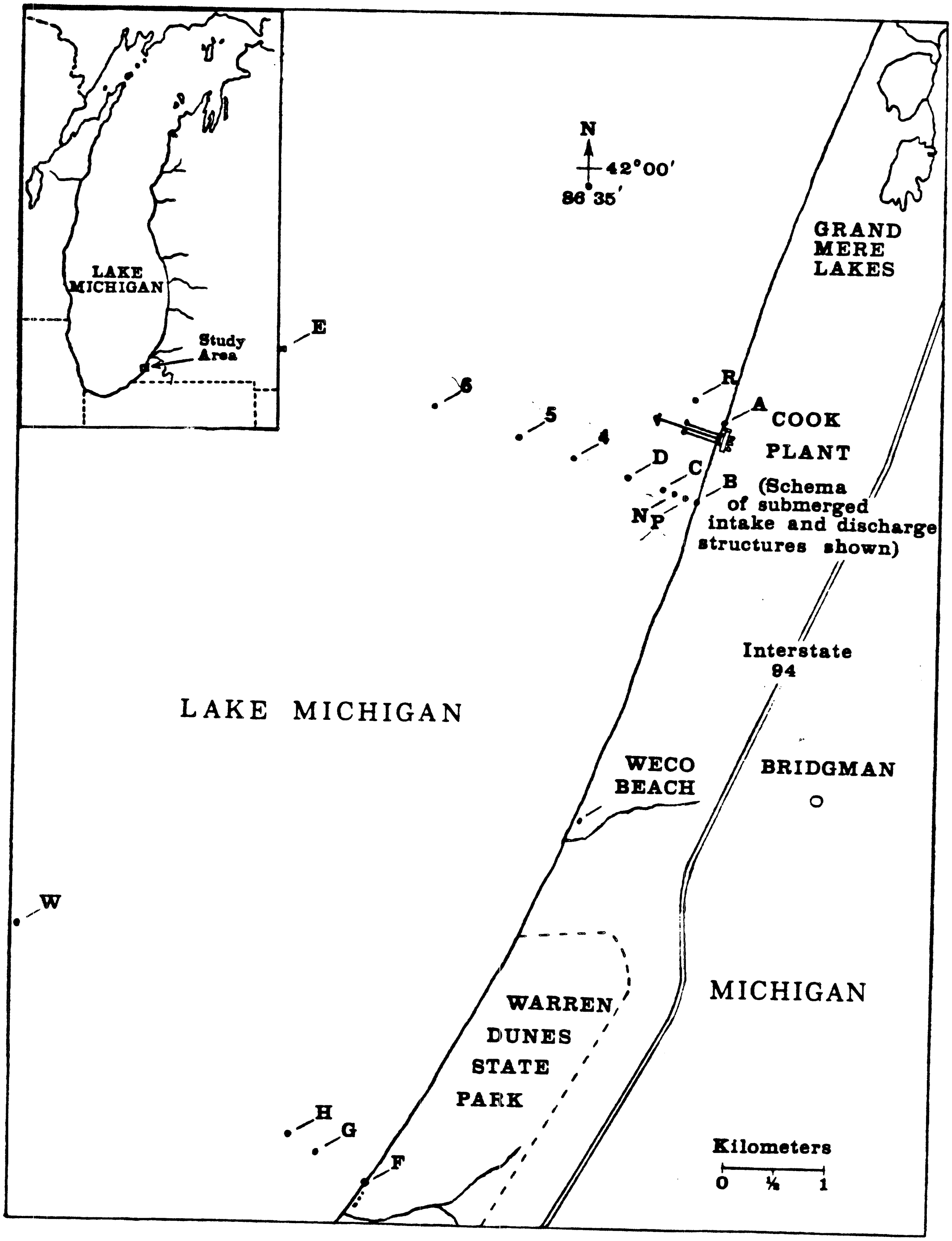


Figure 1. Map of southeastern Lake Michigan, showing locations of the D.C. Cook Plant and our field fish larvae sampling stations.

above lake bottom. Intake openings, protected by a series of steel guard racks, are an additional 2.5 m above the base. Therefore, intake water is drawn from the 2- to 5-m strata of the water column. Three intake pipes with diameters of 4.9 m are buried in the lake bottom and covered by at least 0.6 m of sand (AEC 1973). Estimated water velocity at the intake grills (20 X 20-cm openings) is approximately 0.4 m/s during normal conditions and 0.6 m/s during winter de-icing operations. In the intake pipes, water velocity increases to 1.8 m/s during normal conditions (AEC 1973). Cooling water travels through the intake pipes to a common screenhouse where the seven circulating water pumps are located (Figs. 2 and 3).

Water then passes through vertical trash racks (6-7-cm openings, 0.3 m/s water velocity) and vertical traveling screens (0.95-cm square openings, 0.6-m/s water velocity) to circulating water pumps and condensers. Heated water is discharged via two buried pipes (4.9-m diameter). Discharge structures are 91 m apart and 366 m offshore in 5.5 m of water. Water is discharged at a rapid rate (6,202 m^3/min) through slot-jet diffusers which rapidly mix heated and ambient water. The effluent plume has an estimated area during two-unit operation of 230 ha within the 1.7 C° Δ T (3 F°) isotherm (AEC 1973). A more detailed discussion of intake and discharge structures may be found in Jude et al. (1979b), AEC (1973), and IMPC (1977, 1979). Cooling water passage time from intake at the 7.3-m contour in Lake Michigan to discharge at the lake's 5.5-m contour is approximately 10 min; duration of condenser passage is about 6 s (AEC 1973).

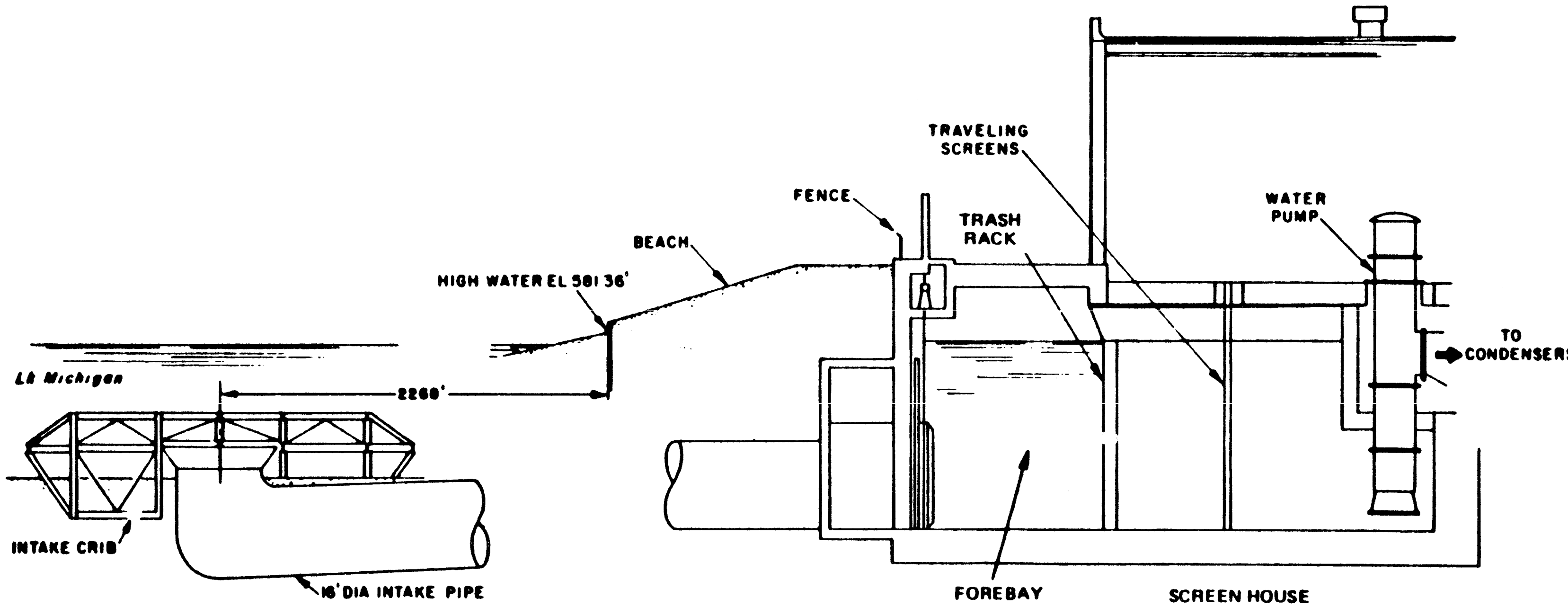


Figure 2. Scheme of the intake crib and screenhouse at the Cook Plant, southeastern Lake Michigan. Adapted from AEC (1973).

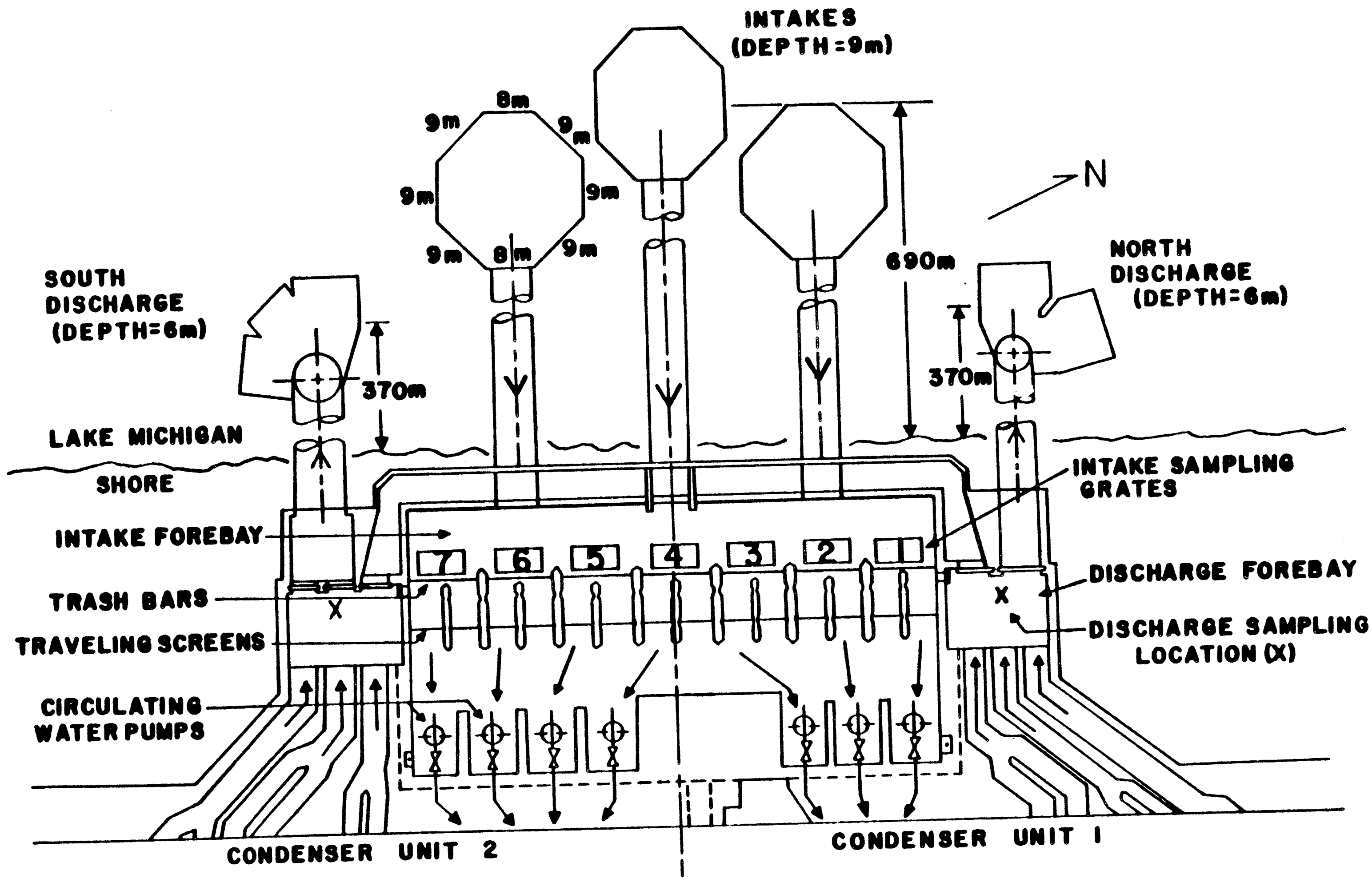


Figure 3. Diagram of the screenhouse and the plant's intake-discharge pipes in Lake Michigan. Also shown are the traveling screens, circulating water pumps and forebay grates where entrainment sampling was conducted.

METHODS

FIELD LARVAE

Sampling

Fish larvae were collected with a conical, 0.5-m diameter, nylon plankton net of no. 2 (363-μm) mesh. A Rigosha flowmeter attached to the center opening of the net measured volume of water sampled. When flowmeters failed to function, we substituted the average of flowmeter values from the remaining tows at the same station or from stations of comparable depth. Flowmeter readings were converted to volume filtered by use of the calibration method in Jude et al. (1979b). One revolution was equal to approximately 15 liters of water filtered.

Duplicate surface tow samples were collected at beach seining stations A (north Cook), B (south Cook), and F (Warren Dunes). A net was towed by hand, just below the water surface, against the current for a distance of about 61 m, once during the day and once at night. Beach tows were performed once a month, April through November.

We performed horizontal, 5-min tows from the R/V Mysis at speeds of 3-6 km/h at discrete depths parallel to shore along three transects in Lake Michigan. The transects were at Warren Dunes, including stations F (1 m, i.e., beach), G (6 m), H (9 m), and W (21 m); south Cook, with stations B (1 m), C (6 m), D (9 m), and E (21 m); and north Cook, with stations A (1 m) and R (6 m) (Fig. 1). Open water tows were performed both day and night, once per month, April through September (1980-1981) and April through August (1982). Stations E and W (21 m) were not sampled after May 1982. For 6-m stations a tow was done at 0.5, 2, 4, and 5.5 m; for 9-m stations depths were 0.5, 2.5, 4.5, 6.5, and 8.5 m; and for 21-m stations tows were done at 0.5, 7.5, 13.5, and 20 m.

The procedure for deepwater tows was as follows:

1) Plankton net with attached Mason jar and depressor lowered to desired depth on end of cable.

2) Plankton net towed horizontally for 5 min starting at the desired depth, which was obtained by measuring cable angle and trigonometrically calculating the length of cable to be released to reach desired depth.

3) Plankton net hauled to surface and washed with a water hose.

4) Contents rinsed into the Mason jar, preserved with 40 ml of buffered formaldehyde, labelled, and sealed.

Total numbers of larvae and eggs captured in all subsurface tows were adjusted to compensate for upper strata contamination. For details of calculation see Jude et al. (1979b). Numbers of eggs and larvae were converted to densities, i.e., number/1,000 m^3, for all analyses. About 35 m^3 of water were filtered during most tows.

Statistical Analyses

ANOVA was applied to fish egg density and larval fish density data (no/1,000 m^3) of four species: alewife, yellow perch, spottail shiner, and rainbow smelt. All ANOVA designs were Model I, full factorial, balanced designs calculated with the statistical package BMD8V (unpublished ms. Statistical Research Laboratory, Univ. Mich., Ann Arbor, Mich. 48109). To approach the assumptions of the model more closely, densities were transformed using log (density + 1). Data from two zones, beach and open water, were analyzed separately. In the beach zone, factors used in ANOVA included Year (1973-1982), Month (June-August), Station (A, north Cook; B, south Cook; and F, Warren Dunes), and Diel Period (day and night) for alewife and fish eggs. Factors used in ANOVA applied to spottail shiner data were Year (1973-1982), Month (June-August), and Station (A, B, F). Due to excessive daytime net avoidance exhibited by spottail shiner larvae, only nighttime samples were included in the analyses. Larval rainbow smelt were abundant enough during May of some years to apply ANOVA tests. Factors utilized in analyses of larval rainbow smelt densities included Year (1974-1975, 1980-1982), Station (A, B, F), and Diel Period. Yellow perch larvae were too scarce in the beach zone for examination with ANOVA.

In the open water zone, factors used in the analysis of alewife larvae densities included Year (1973-1982), Month (June-August), Area (Cook and Warren Dunes), Depth (6- and 9-m contours), and Diel Period. Year (1974-1975, 1979-1982), Area, and Depth were the factors used in ANOVA applied to spottail shiner density data. Only nighttime samples taken in July from the open water zone contained enough spottail shiner larvae to be examined using ANOVA. Factors used in ANOVA applied to larval rainbow smelt density data included Year (1974-1975, 1980-1982), Area, Depth, and Diel Period. Only data from the month of May were utilized in rainbow smelt ANOVA. Larval yellow perch were abundant enough in the open water zone during June of some years for examination using ANOVA. Factors used for yellow perch analyses were Year (1973-1974, 1977-1982), Area, Depth, and Diel

Period. Factors used for fish eggs in the open water zone were Year (1974-1982), Month (June-July), Area, and Depth, but only night data were included.

Because preliminary tests showed no significant trend in larval fish densities among depth strata (surface to near bottom) for a given sampling site and time, samples from different depth strata from the same site and time (day or night) were used as replicates in the ANOVAs of open water stations. Since larval fish samples were taken at 2-m intervals in open water, stations at 6 m, (C, south Cook, and G, Warren Dunes) had one less replicate than 9-m stations (D, south Cook, and H, Warren Dunes). To balance the design, the mean of densities from the four strata at 6-m stations replaced the missing 8-m value. The unweighted means method for balancing designs (Fox, D. J., unpublished ms, Statistical Res. Lab., Univ. Mich., Ann Arbor, MI 48109) was then applied to the open water results. Treatment sums of squares were multiplied by the ratio of harmonic mean cell size to maximum cell size to adjust for substitutions, and the number of missing values was subtracted from degrees of freedom of the error term to adjust mean square error.

ENTRAINMENT

Sampling

Species and numbers of larvae and eggs entrained at the Cook Plant have been monitored by standardized sampling since 1974. However, sampling in 1974 was limited because of the sporadic testing of condenser cooling systems. These data are presented in detail in Jude (1976) and Jude et al.(1979b). Bimber et al. (1984) analyzed data collected from 1973 to 1979. This report will emphasize analysis of data collected during operational years 1980 to 1982, and will include an overview of field larvae collections from 1973 to 1982 and entrainment losses at the Cook Plant from 1975 to 1982.

An entrainment sampling unit included a Hale (type 30LC-1750) diaphragm pump (maximum capacity, 300 liters per minute; mean capacity, 208 liters per minute) with a 7.6-cm diameter steel pipe extending into the intake forebay to a depth of 5 m (Fig. 4). The 5-m depth (maximum depth in the forebay is 9 m) was chosen because of results of our vertical and horizontal stratification testing in 1975 (Jude 1976). Water was pumped through a 0.5-m diameter, no. 2 Nitex nylon, 363-μm mesh plankton net suspended in a 208-liter drum. A flowmeter installed in the drum's effluent pipe measured the volume of water filtered. Standard entrainment sampling units (three) were located at grates 2 and 3 and one at the Unit 1 discharge (Fig. 4). Sampling was performed at the Unit 2 discharge on those occasions when

Unit 1 was not operating. Seven grates span the length of the screenhouse forebay floor. Most sampling in 1980-1982 was done at grates 2 and 3. Unit 1 circulation pumps draw most of their water under grates 1, 2, and 3 (Fig. 3).

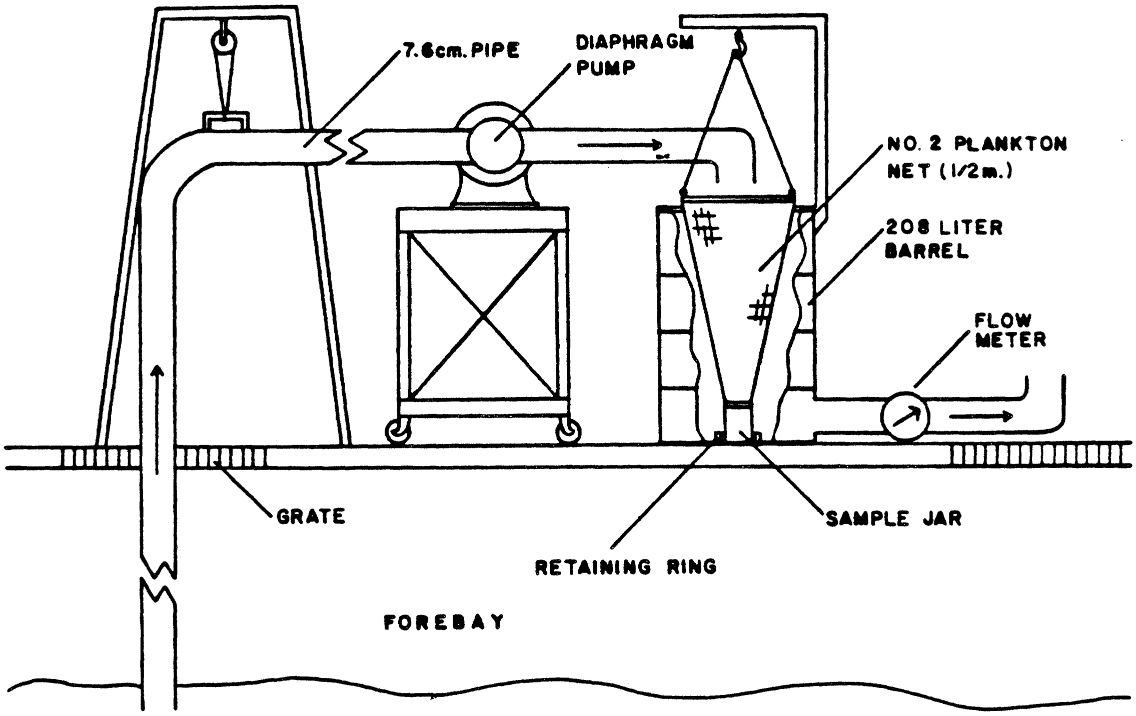


Figure 4. Schematic diagram of an entrainment sampling unit, showing the forebay, sampling pipes, diaphragm pump, plankton net, and flowmeter in the discharge pipe.

Standard series entrainment samples were collected twice per month, except for June, July, and August when sampling was done once per week to coincide with peak abundance of fish eggs and larvae. Sampling was conducted twice per week during June-August 1981 and June-July 1982. Samples were collected over a 24-h period. Each 24-h period was divided into four diel sampling divisions which varied from 4 to 8 h, depending on division and day length. The four divisions were sunrise-noon, noon-sunset, sunset-midnight, and midnight-sunrise. Sixteen samples, four replicates (three intake, one discharge) per division, were collected for each 24-h period.

Densities of larvae and eggs represent a conversion of number per volume sampled (the amount of water pumped through the plankton net) to number per standardized volume (1,000 m^3). These standardized mean densities of larvae and eggs were expanded to the volume of water circulated by the plant during the time represented by that diel period. The total number of fish and eggs entrained over 24 h was computed by totaling estimates from each of the four diel sample divisions during a sample period. Each of these four estimates was derived by multiplying the mean density (n = four) times the total volume of water pumped through the plant during the time represented by that particular division. For yearly estimates, non-overlapping, contiguous time intervals (usually 1-2 wk) were established such that the sampling date was the approximate midpoint of the interval. Estimated entrainment during a sampling period was assumed to be representative of fish larvae and egg abundance per unit volume of circulating water during the 1-2-wk sample interval. The estimated number of fish larvae and eggs entrained was expanded accordingly. These data were totaled for each month and then yearly estimates computed.

Analysis of entrainment data for alewife larvae, total larvae, and fish eggs (log (density + 1) transformed data) was carried out using the Analysis of Variance subprogram of the Statistical Package of the Social Sciences (SPSS) (Nie et al. 1975). A three-factor, fixed-effects, non-additive model was considered most appropriate, with the three factors being: Year, Grate, and Diel Period. To obtain the most balanced model (least amount of missing data) only data from years 1976 through 1982 were examined and data from both discharge grates were combined (since they were not sampled simultaneously). Thus the analysis was across 7 years, four grates, four diel periods, and their associated interactions. Sample size was 1,699. Similar results were obtained for each ANOVA in that the only factors which exhibited attained significance levels less than 0.01 were Year and Diel Period.

Sample Types

The Cook Plant entrainment sampling regime has been modified several times during the course of this study. Four classes of samples describe the use or type of sample collected: standard, supplemental, processed but not used, and not processed (discarded or lost).

Standard series samples were those that could be compared with others in terms of location, duration, and frequency of sampling. Standard samples were collected from grates 2 and 3, and from either the Unit 1 or Unit 2 discharge during any of four diel periods (midnight to sunrise, sunrise to noon, noon to

sunset, or sunset to midnight); depth was 5 m. Volume of water filtered for each sample must have been consistent with volumes of other standard samples collected during the same diel period. A complete standard series sampling set resulted in the collection of 16 samples, 4 samples (3 intake, 1 discharge) from each of the four diel periods.

Supplemental samples were those taken to examine the vertical and horizontal stratification of fish larvae and eggs in the forebay; samples extending across diel periods (i.e., samples taken all night, all day, noon to midnight, midnight to noon, or for 24 h); samples for which inadequate data concerning location of sampling were recorded; and samples taken from grates other than 2, 3, or Unit 1 discharge. Data from supplemental samples were used to support conclusions concerning heterogeneity in the distribution of larvae and eggs in the forebay and to increase the entrainment data base for improving estimates of entrainment losses.

Entrainment samples which were not comparable to others collected during the same time period were removed from the analyses. These samples included: 1) samples in which volumes of water filtered were substantially reduced (less than 75 liters per minute), 2) reduced sampling duration (usually as a result of pump or power failure), or 3) any other problem samples. Samples which were lost, broken, or inadequately preserved comprised this final category. These samples were noted but not included in the entrainment data base.

Entrainment Sampling Adequacy

Over 4,100 entrainment samples, containing nearly 21,400 fish larvae and 603,000 eggs, were processed during 1975-1982 (Tables 1, 2). Standard series samples (see Sample Types) accounted for between 53% (1975) and 98% (1981) of the total number of samples collected in any year. The actual number of larval fish collected in a given year has ranged from 528 (1978) to 4,267 (1982) (Table 2) with a mean of 2,667 larvae/year. Alewife have accounted for over 3/4 of all fish larvae collected in entrainment samples during the 8-yr study period. The number of eggs found in entrainment samples has ranged from 22,418 (1979) to 153,416 (1982) (Table 2) with a mean of 75,315 eggs/ year.

As a result of the large quantity of water used for condenser cooling, current entrainment sampling techniques allow inspection of only a very small fraction of the total intake water volume (Table 3). During 1975-1982 a mean of 0.00165% of the total annual flow was sampled. Sampling effort was increased during June, July, and August in each year (see Sampling) and the

Table 1. Actual numbers (unadjusted) of fish eggs and larvae found in entrainment samples from the D. C. Cook Plant forebay, 1975-1982. Data include all entrainment samples collected.

Species	Sample category				
	Standard series	Supplemental series	Discarded samples	Total	Percent total
Alewife	13,798	2,853	38	16,689	78
Spottail shiner	1,579	200	7	1,786	8
Yellow perch	406	8		414	2
Johnny darter	106	46		152	1
Rainbow smelt	374	25	6	405	2
Trout-perch	53	13		66	0.3
Mottled sculpin	39	6	1	46	0.2
Slimy sculpin	32	9	1	42	0.2
Common carp	15	5		20	<0.1
Deepwater sculpin	2			2	<0.1
Burbot	10			10	<0.1
Ninespine stickleback	9			9	<0.1
Quillback	5			5	<0.1
Unidentified sculpins	44	5		49	0.2
Unidentified minnows	50	5		55	0.2
Unidentified darters	1	2		3	<0.1
Unidentified coregonids	1			1	<0.1
Poor condition larvae	1,423	202	6	1,631	8
Unidentified fish larvae	5	5		10	<0.1
Total larvae	17,952	3,384	59	21,395	
Fish eggs	459,064	143,455	409	602,928	

Table 2. Actual numbers (unadjusted) of fish eggs and larvae found in entrainment samples from the D. C. Cook Plant forebay, 1975-1982. Data include standard series and supplemental entrainment samples.

Species	Year								Total
	1975	1976	1977	1978	1979	1980	1981	1982	
Alewife	3,310	2,646	1,437	395	1,634	979	3,453	2,797	16,651
Spottail shiner	180	36	209	24	41	433	206	650	1,779
Yellow perch	4	2	137	43	22	13	83	110	414
Johnny darter	3	17	52	10	42		6	22	152
Rainbow smelt	36	20	6	5	24	57	42	209	399
Trout-perch	15	6	5	1	12	7	9	11	66
Mottled sculpin	9	6	3		14		6	7	45
Slimy sculpin	9	3	1	2		7	13	6	41
Common carp		5	1	2	7	1	4		20
Deepwater sculpin				1	1				2
Burbot		1		1				8	10
Ninespine stickleback				1		4	3	1	9
Quillback			1				4		5
Unidentified sculpins	6	4	5	4	9	4	7	10	49
Unidentified minnows			3		17	5	2	28	55
Unidentified darters			3						3
Unidentified coregonids			1						1
Poor condition larvae	382	113	23	37	132	122	408	408	1,625
Unidentified fish larvae	6	1	1	2					10
Total larvae	3,960	2,860	1,888	528	1,955	1,632	4,246	4,267	21,336
Fish eggs	36,260	125,895	85,910	85,776	22,418	58,121	34,723	153,416	602,519

Table 3. Comparison of condenser water flow and volumes of water filtered for entrainment samples (both in 1,000's of m^3) at the D. C. Cook Plant, southeastern Lake Michigan, 1975-1982.

	Annual volume			June-August volume		
Year	Cook Plant	Entrainment	% sampled by entrainment gear	Cook Plant	Entrainment	% sampled by entrainment gear
1975	1,297,804	22.9	0.00176	333,237	11.4	0.00342
1976	1,291,865	32.7	0.00253	373,688	16.2	0.00434
1977	1,137,723	25.8	0.00227	320,469	14.5	0.00452
1978	2,369,699	25.1	0.00106	668,564	10.7	0.00160
1979	2,475,630	25.5	0.00103	585,561	11.9	0.00203
1980	2,830,000	21.8	0.00077	565,600	8.2	0.00145
1981	2,753,100	32.4	0.00118	598,000	17.9	0.00299
1982	2,749,400	34.7	0.00126	586,900	18.4	0.00314

percentage of cooling water sampled increased to 0.00294% for the 3-mo period. During one-unit operation (1975-1977) June-August sample volumes were 0.00409% of the total; during 1978-1982, when two units were on-line, sample volumes dropped to 0.00224% of the total June-August flow.

Sampling During 1980-1982--

Entrainment sampling during the final years of our study was very consistent. Standard series sampling was conducted at grates 2, 3S, and 3N and the Unit 1 or Unit 2 discharge at a depth of 5 m (Tables 4-6). When Unit 1 was not operating, Unit 2 discharge samples were substituted for standard series sampling. Samples were collected twice per month, except in June-August 1980 and August 1982 when sampling occurred weekly and in June-August 1981 and June-July 1982 when samples were taken twice each week. Supplemental samples (miscellaneous long duration or non-standard-series location entrainment samples) were collected during June-July 1980, August 1981, and July-September 1982. For a description of sampling during 1974-1979 see Jude et al. (1979b) and Bimber et al. (1984).

Forebay Heterogeneity Studies--

Stratification of organisms within the water column is a potential source of error in any entrainment sampling program. The subject is often ignored, or statements about the highly mixed nature of the cooling water are used to justify arbitrarily chosen sampling locations.

During 1974 and 1975 studies were conducted in the forebay at the D. C. Cook Plant to determine whether fish larvae and eggs were clumped horizontally or vertically in the water column. Sampling was performed at depths of 2, 5, and 8 m and ANOVA examination showed no significant difference for total fish larvae, alewife larvae, or fish egg densities with depth (Jude 1976, Jude et al. 1979b, Bimber et al. 1984). Although the differences were not statistically significant, the 5-m sample means were greatest for all three categories and thus 5 m was selected as the depth at which standard series sampling would be carried out. The horizontal distribution study likewise revealed no statistically significant differences among sampling locations (i.e., different grates) in the forebay (Jude 1976, Jude et al. 1979b, Bimber et al. 1984).

As in previous years (see Bimber et al. 1984), data collected from 1980 to 1982 were examined for evidence of fish larvae and egg stratification in the forebay. ANOVA was used to compare differences in densities among the various standard

Table 4. Locations and numbers of entrainment samples collected in the forebay at the D. C. Cook Plant in 1980. Depth: depth (m) of sampling in the forebay. Grate: the location of the forebay grate, see Figure 3 for reference - (2) grate 2, (3N) grate 3-north, (3S) grate 3-south, (U1) Unit 1 discharge, and (U2) Unit 2 discharge. Data represent both standard series and supplemental entrainment samples.

			Grate				
Month	Total no. samples	Depth (m)	2	3N	3S	U1	U2
Jan	34	5	8	8	8	2	8
Feb	31	5	8	8	7	4	4
Mar	30	5	8	7	8		7
Apr	36	5	8	8	8	3	9
May	31	5	8	8	8		7
Jun	64	5	16	16	16	4	12
Jul	46	5	10	12	12	8	4
Aug	64	5	16	16	16	4	12
Sep	31	5	8	8	8		7
Oct	26	5	7	5	6		8
Nov	32	5	8	8	8		8
Dec	32	5	8	8	8		8
Total	457		113	112	113	25	94

Table 5. Locations and numbers of entrainment samples collected in the forebay at the D. C. Cook Plant in 1981. Depth: depth (m) of sampling in the forebay. Grate: the location of the forebay grate, see Figure 3 for reference - (2) grate 2, (3N) grate 3-north, (3S) grate 3-south, (U1) Unit 1 discharge, and (U2) Unit 2 discharge. Data represent both standard series and supplemental entrainment samples.

			Grate				
Month	Total no. samples	Depth (m)	2	3N	3S	U1	U2
Jan	32	5	8	7	9		8
Feb	32	5	8	8	8		8
Mar	31	5	8	8	7		8
Apr	32	5	8	8	8		9
May	31	5	8	6	9		8
Jun	119	5	30	29	30	30	
Jul	118	5	30	28	30	30	
Aug	126	5	32	30	32	4	28
Sep	32	5	8	8	8		8
Oct	32	5	8	8	8		8
Nov	32	5	8	8	8	4	4
Dec	31	5	8	7	8	4	4
Total	648		164	155	165	72	92

Table 6. Locations and numbers of entrainment samples collected in the forebay at the D. C. Cook Plant in 1982. Depth: depth (m) of sampling in the forebay. Grate: the location of the forebay grate, see Figure 3 for reference - (2) grate 2, (3N) grate 3-north, (3S) grate 3-south, (U1) Unit 1 discharge, and (U2) Unit 2 discharge. Data represent both standard series and supplemental entrainment samples.

			Grate				
Month	Total no. samples	Depth (m)	2	3N	3S	U1	U2
Jan	32	5	8	8	8		8
Feb	32	5	8	8	8	8	
Mar	32	5	8	8	8		8
Apr	32	5	8	8	8		8
May	32	5	8	8	8		8
Jun	134	5	34	34	33		33
Jul	143	5	36	36	36	17	18
Aug	64	5	16	16	16	16	
Sep	36	5	9	9	9	6	3
Oct	29	5	8	7	8		6
Nov	32	5	8	8	8		8
Dec	32	5	8	8	8		8
Total	630		159	158	158	47	108

series sampling locations. No significant differences in densities of total larvae or alewife larvae occurred among samples collected at grates 2, 3N, 3S, and Unit 1 or 2 discharge during 1980-1982 (Table 7) or during 1976-1982 (Tables 8,9).

There was no significant difference in egg densities among sampling locations for all years combined. The ANOVA with the most balanced design included 1976-1982 with egg densities from Units 1 and 2 discharges pooled (Table 10). When Units 1 and 2 discharges were treated separately in the ANOVA, there were significant differences in egg densities among grates in 1981 and and 1982 ($p < 0.001$). Mean densities for June-August 1982 were 13 eggs/1,000 m^3 at Unit 1, and 2 eggs/1,000 m^3 at Unit 2. However, when 1982 data for Units 1 and 2 discharges were combined, their mean (9 eggs/1,000 m^3) was similar to those of the other grates (10-11 eggs/1,000 m^3) so that no difference was detectable (Table 7). During 1979 and 1981, mean egg densities at Unit 2 discharge were much higher than at Unit 1 discharge, in contrast with 1982. These results caused a significant YEAR x GRATE factor interaction for the years 1978-1982 ($p < 0.001$). The differences between discharges were probably due to a combination of discharge design, flow rates, and demersal nature of the eggs, which dictated whether eggs were mixed throughout forebay waters, and hence, susceptibility to our pumps. An unanswered question is whether adult fish impinged on the traveling screens released eggs which could be collected in discharge samples. However, there is no reason to believe that this would occur with greater frequency at one discharge than the other. Analysis of the data showed egg densities were not significantly higher at the discharges than the intakes, thus egg release by impinged fish is probably small in comparison to total eggs entrained.

Field-Entrainment Comparisons

Field and entrainment catches were compared for abundance and size of alewife larvae and abundance of fish eggs in an effort to determine if larvae and eggs were entrained in proportion to their abundance in the lake. Each set of monthly field samples (June-August, day and night separately) was paired with the set of entrainment samples taken on the nearest date, during the same diel period. Relative abundance was determined by comparing densities (no./1,000 m^3) of larval alewife in each pair of samples. The density computed for each diel period of entrainment sampling was the mean of eight replicates (day = dawn to noon and noon to dusk samples combined; night = dusk to midnight and midnight to dawn). Entrainment densities were compared to densities from field stations in close proximity to the intakes (i.e., 9-m station D and 6-m stations C and R). Field densities for a given diel period therefore represented a

Table 7. Results of an ANOVA of factors potentially affecting entrainment densities. June, July, and August standard series data for total larvae, alewife larvae, and fish egg (log catch+1) densities are included. (* indicates significance at the 0.01 level.)

		ANOVA Factor	
Year	Category	Grate	Diel period
1980			
	Total larvae	0.948	0.111
	Alewife larvae	0.966	0.114
	Fish eggs	0.983	0.374
1981			
	Total larvae	0.542	0.046
	Alewife larvae	0.506	0.041
	Fish eggs	0.000*	0.021
1982			
	Total larvae	0.024	0.000*
	Alewife larvae	0.029	0.000*
	Fish eggs	0.964	0.000*

Table 8. Analysis of variance summary of densities (no./1,000 m^3) of fish larvae (all species combined) collected during 1976-1982 in the D. C. Cook Plant forebay. Signif.= Attained level of significance.

Source of variation	df	Mean square	F-statistic	Signif.
Year (Y)	6	1,486,287.000	5.967	0.000
Grate (G)	3	306,075.438	1.229	0.298
Diel Period (D)	3	6,663,445.000	26.750	0.000
Y X G	18	157,392.125	0.632	0.877
Y X D	18	314,088.375	1.261	0.204
G X D	9	51,771.805	0.208	0.993
Y X G X D	54	78,466.438	0.315	1.000
Explained	111	388,372.750	1.559	<0.001
Residual	1,587	249,102.500		
Total	1,698	258,206.750		

Table 9. Analysis of variance summary of densities (no./1,000 m^3) of alewife larvae collected during 1976-1982 in the D. C. Cook Plant forebay. Signif. = Attained level of significance.

Source of variation	df	Mean square	F-statistic	Signif.
Year (Y)	6	767,996.500	4.900	0.000
Grate (G)	3	198,950.250	1.269	0.283
Diel Period (D)	3	3,475,918.000	22.177	0.000
Y X G	18	101,601.688	0.648	0.863
Y X D	18	157,888.688	1.007	0.448
G X D	9	24,206.965	0.154	0.998
Y X G X D	54	53,404.387	0.341	1.000
Explained	111	211,533.250	1.350	0.011
Residual	1,587	156,736.875		
Total	1,698	160,319.000		

Table 10. Analysis of variance summary of log (density + 1) of fish eggs collected during 1976-1982 in the D. C. Cook Plant forebay. Signif. = Attained level of significance.

Source of variation	df	Mean square	F-statistic	Signif.
Year (Y)	6	22.280	10.698	0.000
Grate (G)	3	0.597	0.243	0.866
Diel Period (D)	3	38.801	15.795	0.000
Y X G	18	1.676	0.682	0.832
Y X D	18	2.404	0.979	0.482
G X D	9	0.110	0.045	1.000
Y X G X D	54	0.190	0.077	1.000
Explained	111	3.287	1.338	0.013
Residual	1,587	2.457		
Total	1,698	2.511		

mean of 13 samples: (mean of C+R (N=8) + mean of D (N=5))/2. A weighted average was used to equalize the contribution of 6- and 9-m stations.

Because alewife eggs can hatch in 3 days at the 20-23 °C temperatures typical of Lake Michigan in summer (Auer 1982) and because intermittent upwellings and movement of water masses can transport larvae to and from the nearshore zone (Heufelder et al. 1982), sample pairs taken more than 2 days apart were excluded from the analysis (10 cases). Field densities were greater than entrainment densities in 32 of the remaining 38 cases (84% of the time).

Field and entrainment samples were paired the same way for length comparisons as for abundance comparisons. Sample sets taken more than 2 days apart were again excluded as were samples containing fewer than five larvae (three additional cases).

ESTIMATION OF ALEWIFE SURVIVAL

Introduction

Survival of alewife during the first growth season was estimated as follows. Because alewife spawning and hatching are continuous over 1.5 months or longer, it was impossible to identify a cohort and follow it through the season. Thus data for larvae and YOY were pooled through the season and treated as one cohort. Fish were separated by length intervals but not by sampling period.

Densities of Alewife Larvae

Densities of alewife larvae used in the analysis were obtained from both field and entrainment samples. Entrainment densities were calculated for each year by averaging the densities for each sampling period, then summing the means over all sampling periods (n usually equalled 16) to get a total mean density of larvae pooled through the season. This was done separately for size groups 2-5 mm (newly hatched), 5.5-10 mm, 10.5-15 mm, 15.5-20 mm, 20.5-25 mm, and 5.5-25 mm pooled, separately for each year. An estimate of growth rate is necessary to obtain survival rates from length-frequencies (Farris 1960, May 1974). Alewife larvae in the laboratory grow at rates of 3.5 to 4.6 mm per wk (Heinrich 1981, Kellogg 1982) and take an average of 5 wk to grow to 25 mm (Heinrich 1981). Entrainment samples were usually collected once a week, so fish larvae hatched at a given time could be sampled three or four

times during their growth from 5.5 to 25 mm. Therefore, larvae 5.5-25 mm were separated into size groups so that total density over the season would not include the same age group more than once. Samples were taken twice weekly during 1981 and 1982, so 1981-1982 total entrainment densities were halved to make them comparable with all other years. All diel periods were combined.

Only field larvae samples from stations 6 and 9 m in depth (C, D, and R - Cook, G and H - Warren Dunes) were used in the analysis, because these were the depths for which trawl data were available. Densities were averaged over all depth strata and stations, then summed over the months alewife larvae were collected (usually June through August, sometimes including September). Samples from the diel period showing greatest abundance of alewives were used, usually night. Some day sample densities were higher than for night, and were used during 1977, 1978, 1979, and 1980. Densities of newly hatched larvae were calculated separately from densities of larvae >5 mm, but larvae >5 mm were not subdivided further because field sampling was conducted monthly, and this was a long enough time for most to grow from 5 to 20 mm. So few larvae 20-25 mm were collected that their densities did not significantly affect results. Field larvae data from 1973 were not included because different strata were sampled that year and would bias results.

Densities of YOY Alewives

Size and shape of the trawl mouth were estimated from published studies of trawls in motion, along with measurements of our trawl on land. Amos et al. (1981) used a towing tank to test an otter trawl which was constructed like ours (only somewhat larger). Lengths of headrope, footrope, vertical line, and bridle were compared between their tested trawl and ours (Table 11). Proportions of these measurements and Amos et al.'s measurements of trawl mouth size during towing were used to estimate likely size and shape of our trawl mouth opening. These estimates were compared with results obtained by Hatch et al. (1981), who found a somewhat larger vertical opening on a trawl similar to ours; therefore our estimate of vertical opening was adjusted upwards in proportion to the headrope length and vertical opening of Hatch et al.'s trawl. Amos et al.'s figures were used for shape and horizontal opening of the trawl. Area was obtained by plotting the dimensions on graph paper.

Distance covered during each trawl was calculated using the average speed during trawling (4,167 m/h) and elapsed time (10 min). Volume of water filtered by the trawl was obtained by multiplying distance by trawl area (2.45 m^2). An estimated 1,701.5 m^3 of water was filtered during each trawl haul. Numbers of YOY in day trawls were averaged over trawl stations of the

Table 11. Trawl size measurements and estimates (in m) used in calculations of alewife survival.

Measured Parameter	Amos et al.	Hatch et al.	Our trawl
Headrope	23.2	11.9	4.9
Footrope	29.2	15.5	5.8
Vertical line	2.1		0.82
Bridle	9.15		0.93
Calculated or estimated size during tows			
Headrope spread	14.0	6.5*	2.8
Footrope spread	17.6		3.5
Height at center	2.3	2.4	0.90
Height at wing end	1.6	0.7	0.62

*Mean of headrope and footrope spread.

same depth, three 6-m stations and two 9-m stations. These numbers were divided by 1.7015 to obtain mean number of YOY/1,000 m^3. Densities were calculated separately for each 10-mm length interval, and were summed over months in which YOY were present at trawl depths and weather permitted sampling, usually September, October, and November. Since alewife YOY are believed to concentrate near bottom during the day, densities were multiplied by the height of the trawl divided by the depth of the water column (6 or 9 m), then summed over the two bottom depths. This adjustment made trawl data comparable to field larvae data, which represented the whole water column.

Survival rates, i.e., the ratios of YOY densities to larvae densities, were calculated separately for each year using field and entrainment data for each length interval of larvae, and the density of the most abundant length interval of YOY. The peak length interval was felt to be the truest representation of YOY density, representing the time when most YOY were actually at trawl depths rather than inshore (late summer, smaller fish) or offshore (late fall and winter, larger fish). Densities for each length interval of larvae, and peak-length YOY densities, were also averaged over all years, then used to calculate survival rates for all years combined.

Daily mortality rates were calculated from field and entrainment data using the equations:

$$Z = -(\ln N_{t+1} - \ln N_t)$$

$$n_t = Z/D$$

$$M_t = 1 - e^{(-n_t)}$$

where Z = instantaneous mortality rate from time t to t+1

N_t = density of alewife at time t

n_t = instantaneous daily mortality rate

D = number of days from time t to t+1

M_t = daily mortality rate from time t to t+1

These mortality rates were calculated using mean densities over all years for the various length intervals available. Dates used were derived in two ways: (design I) mean dates of peak catch in each length interval, and (design II) dates for intermediate length intervals calculated from peak dates of yolk-sac larvae catch, and growth rates obtained in the laboratory by Heinrich (1981). Thus if peak catch of yolk-sac (2-5 mm) larvae was 7 July, Heinrich's growth rates indicate larvae should reach successive 5-mm length intervals of 5.5-10, 10.5-15, 15.5-20, and 20.5-25 mm in 7, 16, 23, and 30 days after 7 July, respectively. However, actual time of peak YOY catch was used for the date terminating the analysis, because Heinrich's data do not go beyond 50 days. Thus designs I and II are the same for calculating daily mortality over the entire span, yolk-sac larvae to YOY. Design II calculations involving the 5.5-25 mm interval used 11 days from 2-5 to 5.5-25 mm as the midpoint of growth from 5 to 10 and 10 to 15 mm, which were the intervals above 2-5 mm containing the most larvae.

LABORATORY PROCEDURES

All entrainment and field samples of fish larvae and eggs were preserved with a 10% formaldehyde solution immediately after collection and then transported to the Great Lakes Research

Division's fishery laboratory for analysis. For our purposes, fish larvae were defined as any fish 25.4 mm or less in total length (TL). In the laboratory, larvae were sorted, identified, counted, and measured. Larvae were identified to species, when possible, otherwise to the lowest taxonomic group (see Table 12). Alewife, spottail shiner, and rainbow smelt were measured to the nearest 0.5 mm TL, while all others were measured to the nearest 0.1 mm TL. Eggs were also counted but not identified to species. When large quantities were found, egg numbers were estimated via a volumetric subsampling method (see Jude et al. 1975). All larvae and a subsample of eggs from each entrainment sample were then catalogued and saved for future reference. Data were recorded directly on standard coding forms, keypunched, and transferred to computer tapes for analysis.

Larval fish identification was based on knowledge of species abundance and spawning times in southeastern Lake Michigan, comparison of specimens with those in the Great Lakes Regional Fish Larvae Collection (Dorr and Jude 1981), and reference to taxonomic works (Auer 1982, Dorr et al. 1976, Hogue et al. 1976, Lippson and Moran 1974, Nelson and Cole 1975, and Jude et al. 1979b). Some fish larvae identifications may be reevaluated and reassignments made, but these taxonomic changes will not affect total entrainment estimates in any year.

Table 12. Ichthyoplankton species and groups entrained or collected in the vicinity of the D. C. Cook Plant from 1973 to 1982. Scientific names from Robins et al. (1980).

Common name or category	Code	Scientific name or category
Alewife	AL	*Alosa pseudoharengus* (Wilson)
Spottail shiner	SP	*Notropis hudsonius* (Clinton)
Rainbow smelt	SM	*Osmerus mordax* (Mitchill)
Yellow perch	YP	*Perca flavescens* (Mitchill)
Trout-perch	TP	*Percopsis omiscomaycus* (Walbaum)
Johnny darter	JD	*Etheostoma nigrum* Rafinesque
Slimy sculpin	SS	*Cottus cognatus* Richardson
Common carp	CP	*Cyprinus carpio* Linnaeus
Ninespine stickleback	NS	*Pungitius pungitius* (Linnaeus)
Mottled sculpin	MS	*Cottus bairdi* Girard
Deepwater sculpin	FS	*Myoxocephalus thompsoni* (Girard)
Burbot	BR	*Lota lota* (Linnaeus)
Quillback	QL	*Carpiodes cyprinus* (Lesueur)
Emerald shiner	ES	*Notropis atherinoides* Rafinesque
Gizzard shad	GS	*Dorosoma cepedianum* (Lesueur)
Unidentified sculpins	UC	*Cottus* spp.
Unidentified minnows	XM	Cyprinidae
Unidentified coregonids	XC	*Coregonus* spp.
Unidentified darters	XE	*Etheostoma* spp.
Unidentified suckers	XS	Catostomidae
Unidentified clupeids	XH	Clupeidae
Unidentified fish larvae as a result of poor condition	XP	
Unidentified fish larvae	XX	
Fish eggs		

RESULTS AND DISCUSSION

OVERVIEW

Summary: Entrainment and Field Larvae Collections

Nearly 750 million fish larvae and 23 billion eggs were entrained at the D. C. Cook Plant during 1975-1982. Estimated annual losses ranged from 33.5 million larvae in 1977 to 167 million larvae in 1982 (Table 13). Differences in the volume of cooling water pumped through the plant each year (Table 14) were responsible, in large part, for the fluctuations in estimated losses. Variations in annual losses are generally caused by a combination of biological and non-biological factors, i.e., fluctuations in year-class strength and differences in plant operation.

Thirteen species of fish larvae were found in entrainment samples during our 8-yr study: alewife, burbot, common carp, deepwater sculpin, johnny darter, mottled sculpin, ninespine stickleback, quillback, rainbow smelt, slimy sculpin, spottail shiner, trout-perch, and yellow perch. In addition, there were four groups that could not be identified to species: coregonines (*Coregonus* spp.), darters (*Etheostoma* spp.), minnows (Cyprinidae), and sculpins (*Cottus* spp.). Approximately 8% of all fish larvae collected during entrainment sampling were damaged beyond recognition and <0.1% could not be identified at our current level of taxonomic sophistication (Table 1, Table 13).

Alewives were by far the most abundant species, accounting for between 54 and 92% of the total number of larvae entrained in every year (Figure 5) and 74% of the overall 8-yr entrainment loss. Spottail shiners represented 9% of the 1975-1982 entrainment loss, rainbow smelt represented 5%, and yellow perch 2%. Remaining taxa each accounted for <1% of the total 8-yr loss (Table 13).

Entrainment of fish larvae generally began for the year in April, peaked in June or July (when alewife spawning and hatching peaked), and terminated in October or November as larvae and young-of-the-year migrated to deeper offshore zones. Entrainment rates were strongly influenced by diel period. Use of ANOVA showed that significantly more fish eggs and larvae were entrained at night (dusk-midnight and midnight-dawn sampling periods) than during the day (dawn-noon and noon-dusk) (Tables 8-10).

Table 13. Estimates (in millions) of annual entrainment losses of fish larvae and fish eggs at the D. C. Cook Plant, southeastern Lake Michigan, 1975 to 1982. Calculations use actual reported flow rates of the circulating water system.

Taxon	Year of estimate								Total	% Total
	1975	1976	1977	1978	1979	1980	1981	1982		
Alewife	63.708	53.7550	27.3888	31.098	125.6180	49.35	111.54	92.425	554.8828	74.34
Spottail shiner	3.41	0.9361	2.760	1.681	1.8228	21.06	7.257	28.2297	67.1566	9.00
Rainbow smelt	1.3608	0.4145	0.1795	0.3496	0.3726	11.954	2.6265	18.5233	35.7808	4.79
Yellow perch	0.17554	0.03807	1.3224	3.0655	0.3840	0.8971	2.506	4.9700	13.3586	1.79
Trout-perch	1.079	0.2509	0.1456	0.0194	0.6288	0.4858	0.5394	1.3749	4.5238	0.61
Johnny darter	0.0440	0.210	0.707	0.772	0.8105		0.153	0.7046	3.4011	0.46
Slimy sculpin	0.2431	0.06092	0.0256	0.130		0.553	1.002	0.4887	2.5033	0.34
Mottled sculpin	0.152	0.146	0.0483		0.131		0.143	0.4870	1.1073	0.15
Common carp		0.0912	0.0235	0.175	0.3603	0.0513	0.187		0.8883	0.12
Ninespine stickleback				0.124		0.379	0.156	0.0112	0.6702	0.09
Quillback			0.0628				0.534		0.5968	0.08
Burbot		0.0202		0.102				0.3428	0.4650	0.06
Deepwater sculpin				0.178	0.0141				0.1921	0.03
Unidentified sculpins	0.1899	0.0892	0.0918	0.175	0.0905	0.667	0.5953	0.5744	2.4731	0.33
Unidentified minnows			0.1248		0.8138	0.2846	0.1714	1.0280	2.4226	0.32
Unidentified coregonids			0.0850						0.0850	0.01
Unidentified darters			0.0276						0.0276	<0.01
Poor condition	6.555	2.8642	0.4274	3.352	5.9935	6.4765	11.859	17.9458	55.4734	7.43
Unidentified larvae	0.1693	0.0349	0.0887	0.100					0.3929	0.05
Total larvae	77.08664	58.91119	33.5088	41.3215	137.0399	92.1583	139.2696	167.1054	746.4013	
Total eggs	743.1879	2269.4543	1320.301	5840.8138	1392.5408	3334.692	995.94	7005.26	22902.1898	

Table 14. Monthly water volume (in millions of cubic meters) pumped through the condenser circulating water system of the D. C. Cook Plant, southeastern Lake Michigan from 1975 to 1982. Unit 1 has been operational since January 1975, Unit 2 since February 1978.

Month	1975	1976	1977	1978	1979	1980	1981	1982
January	64.9	85.7	24.9	114.4	273.2	142.5	270.8	275.7
February	75.6	88.5	54.5	121.6	275.2	280.9	282.5	177.8
March	117.7	103.6	118.7	207.1	281.9	314.4	213.6	195.5
April	121.0	76.2	114.5	115.9	173.7	304.5	128.8	291.8
May	125.8	86.0	97.4	90.4	100.5	318.4	196.5	308.6
June	122.8	122.7	93.5	194.4	33.3	167.6	165.0	309.2
July	81.7	120.5	103.6	224.5	227.7	101.0	142.4	190.3
August	128.7	130.5	123.3	249.6	324.6	297.0	290.6	87.4
September	125.2	109.0	97.7	277.6	314.3	303.1	305.0	206.4
October	132.2	137.9	112.4	298.8	245.9	247.7	182.4	296.1
November	90.6	126.2	76.3	202.8	107.3	125.8	265.3	265.2
December	111.6	105.1	120.9	272.5	118.0	227.1	310.2	145.4
Annual total	1,298	1,292	1,138	2,370	2,476	2,830	2,753	2,749

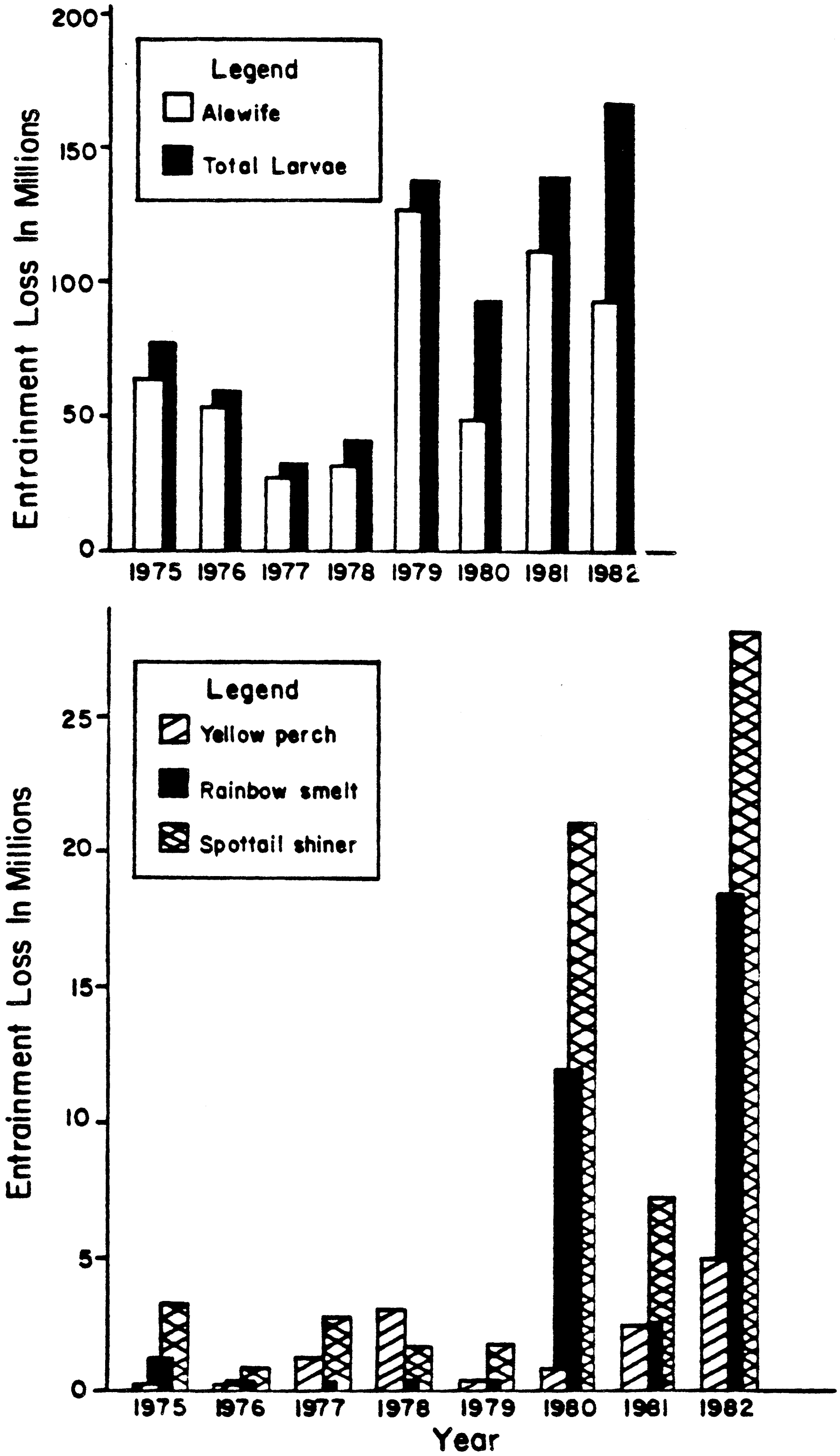


Figure 5. Entrainment losses at the D.C. Cook Plant, southeastern Lake Michigan, 1975-1982, for alewife, yellow perch, rainbow smelt, spottail shiner, total larvae, and fish eggs.

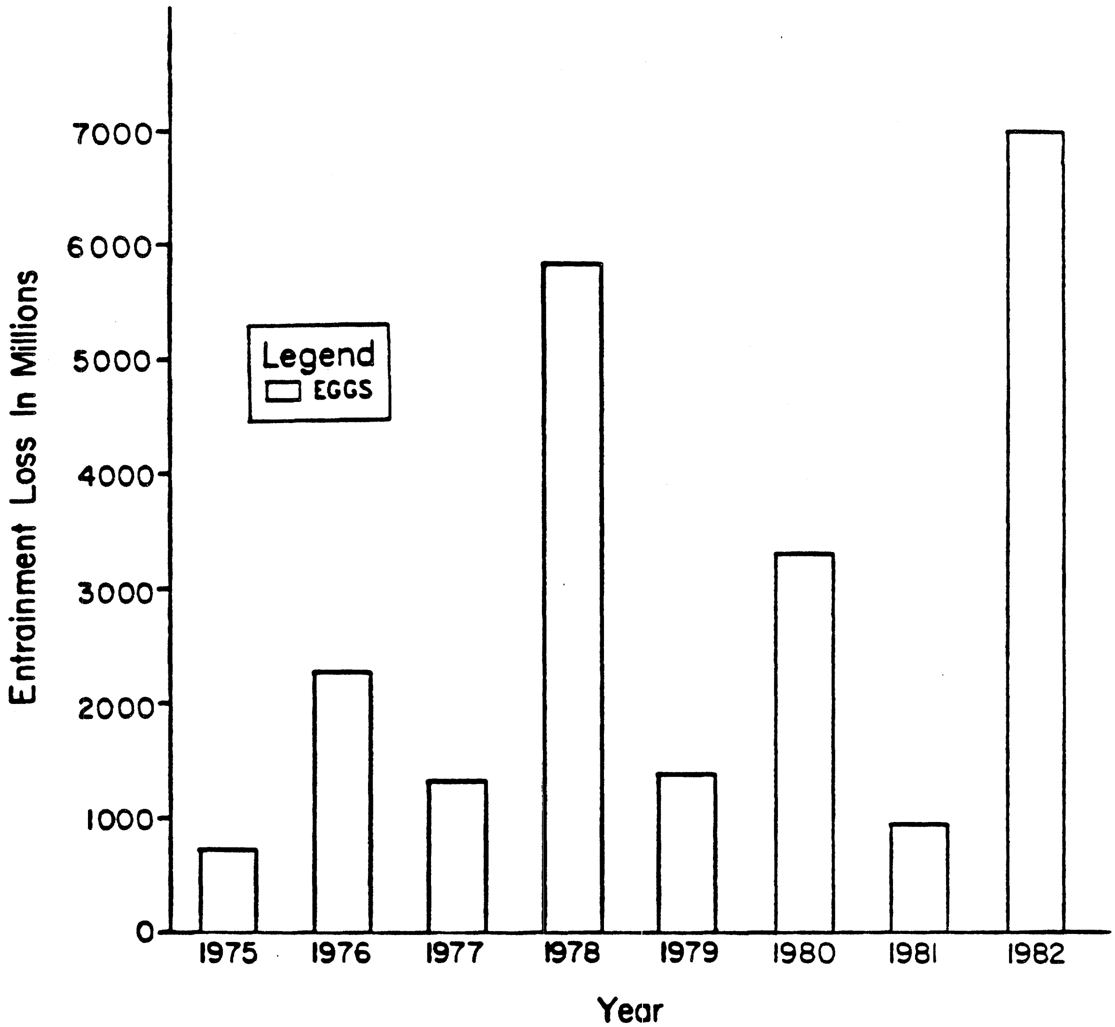


Figure 5. Continued.

Nineteen taxa of fish larvae were identified from our field samples during the 10-yr study. Alewife dominated collections in every year. Spottail shiner, yellow perch, and rainbow smelt were also present in all years, but in much smaller numbers than alewife. Burbot, common carp, johnny darter, and trout-perch larvae appeared in field samples occasionally. The remaining taxa, deepwater sculpin, emerald shiner, gizzard shad, ninespine stickleback, slimy sculpin, quillback, and unidentified members of the whitefish, herring, minnow, sculpin, and sucker families were rare; each was present in only 1 or 2 years.

Larvae first appeared in field samples in April or May and became most abundant during summer months (June-August) when spawning was heaviest. The last larvae of the season were collected in September, October, or November. Rainbow smelt, burbot, yellow perch, deepwater sculpin, and alewife were among the earliest larvae to appear during our field season; alewife, and occasionally trout-perch, were the latest.

June, July, and August samples contributed between 80 and 99% of the total number of larvae collected in each year. July was usually the month of highest mean densities of larval fish at both beach and open water stations, followed by June, and then August. During the summer, monthly mean densities were almost always higher at beach stations than at open water stations. Generally, more larval fish were caught during night sampling than during day sampling.

Plant Impact

There were few indications of Cook Plant effects on distributions of fish larvae. Statistical tests performed on densities of larval fish species which were consistently abundant enough for analysis showed few significant differences. Mean alewife abundance did not differ significantly between Cook and Warren Dunes stations (ANOVA: $p = 0.3775$ for beach stations, $p = 0.5758$ for open water stations) over the 10 years of data collection. Densities of spottail shiner larvae in night beach station samples did not differ significantly between areas (ANOVA, $p = 0.8415$). Yellow perch were at depressed levels during all but the last year of our study, due to the impact of the alewife (Christie 1974; Jude et al. 1979a; Crowder 1980; Jude and Tesar 1985). Yellow perch larvae abundance followed no patterns attributable to plant operations. Yellow perch larvae were abundant in both Cook and reference areas in 1974, 1977, and 1982, but not in other years. During operational years 1977 to 1982, open water yellow perch densities were not significantly different between Cook and Warren Dunes stations (Kruskal-Wallis, $p = 0.768$). Additionally, no significant difference existed between preoperational and operational years for June open water

yellow perch densities (Kruskal-Wallis, $p = 0.155$). Beach catches of rainbow smelt larvae during 1974, 1975, and 1980-1982 did not differ significantly between Cook and Warren Dunes stations (ANOVA, $p = 0.48$). In the open water, densities at Cook were significantly higher than at Warren Dunes (ANOVA, $p = 0.0015$) when preoperational and operational years were combined (1974, 1975, and 1980-1982). This significance was due to the unusually high catches at 6- and 9-m Cook stations during May 1974. During operational years (1975 and 1980-1982), however, no significant difference between Cook and Warren Dunes open water stations (C and D vs. G and H) was observed (Kruskal-Wallis, $p = 0.02$). These data suggest no plant impact on larval rainbow smelt populations.

Of the less abundant species, the most striking abundance pattern was that of common carp larvae. Common carp larvae were never collected in the study area during preoperational years. During operational years, they were found mostly at Cook stations. Of the 23 samples containing common carp larvae, only 2 were collected at Warren Dunes. These data suggest that common carp spawning took place at Cook Plant stations during operational years, which we attributed to the attraction of the warm water plume and currents produced by the heated discharge of the Cook Plant. Thus common carp spawning at the Cook Plant was a clear plant effect. Common carp larvae were collected at Warren Dunes at relatively low densities (31 larvae/1,000 m^3 and 83 larvae/1,000 m^3). These larvae probably drifted from the Cook Plant area.

Burbot, deepwater sculpin, and ninespine stickleback larvae showed no apparent differences between Cook and reference areas. Quillback, unidentified Coregoninae, gizzard shad, emerald shiner, and others, identified only to genus or family (minnows, darters, sculpins), were collected so seldom that no difference could be ascertained. Several other species not abundant enough for statistical testing were more abundant at Cook than at the reference area. During the 10-yr study, 14 samples contained trout-perch larvae, and 10 of these were from Cook stations. More johnny darter and slimy sculpin larvae were collected at Cook than at reference stations, probably because riprap around the intake attracts these species for spawning.

DESCRIPTIONS BY SPECIES

Alewife

Entrainment--

<u>General trends</u>-- Alewife larvae have represented the largest component of entrainment loss in every year of our study, consistently accounting for over half the total number of fish larvae entrained (Fig. 5). Annual entrainment estimates for alewife larvae ranged from 27.4 million (1977) to 125.6 million larvae (1979) and the proportion of total annual entrainment attributable to alewife has ranged from 54% (1980) to 92% (1979) (Table 13).

The apparently extraordinary susceptibility of alewives to entrainment is probably a result of several factors. Alewife is the most abundant fish species in the vicinity of the Cook Plant (Jude et al. 1979b, Tesar et al. 1985) and in Lake Michigan as a whole (Smith 1968) and it is therefore not surprising to see them so well represented in entrainment samples. Further, alewives are pelagic broadcast spawners which produce large numbers of eggs (10,000-22,407/female, Auer 1982) and larvae compared with species that provide some form of protection for embryos and larvae (e.g., sculpin).

Alewife susceptibility to entrainment is also enhanced by temporal and spatial characteristics of their spawning and hatching and distribution of their larvae. In spring or early summer, adult alewives move inshore to spawn and come within the realm of influence of the intakes. Peak hatches generally occur in June or July when demand for electricity, and therefore cooling water requirements, are also at a peak. The pelagic nature of alewife larvae increases their vulnerability to entrainment. In addition, larval alewives are among the most frail and least developed at hatching of all Great Lakes fish larvae which probably makes them less able to avoid water intakes than the larvae of many other, more robust species.

<u>Seasonal abundance</u>-- Season of occurrence for alewife larvae generally begins in the spring as water temperatures approach 15 °C and extends through the summer months and into the fall. This period corresponds to the period of warmest water temperatures in the vicinity of the Cook Plant (Figs. 6-8, Bimber et al. 1984). Larval alewife were first entrained in April (1977), May (1975, 1976, 1978), or June (1979-1982), became most abundant in June (1975, 1981) or July (1976-1980, 1982) (Tables 15-17, Figs. 9-11) and continued to be present in entrainment samples during nearly every month until September (1975, 1977, 1980, 1981), October (1976, 1982), or November (1978, 1979).

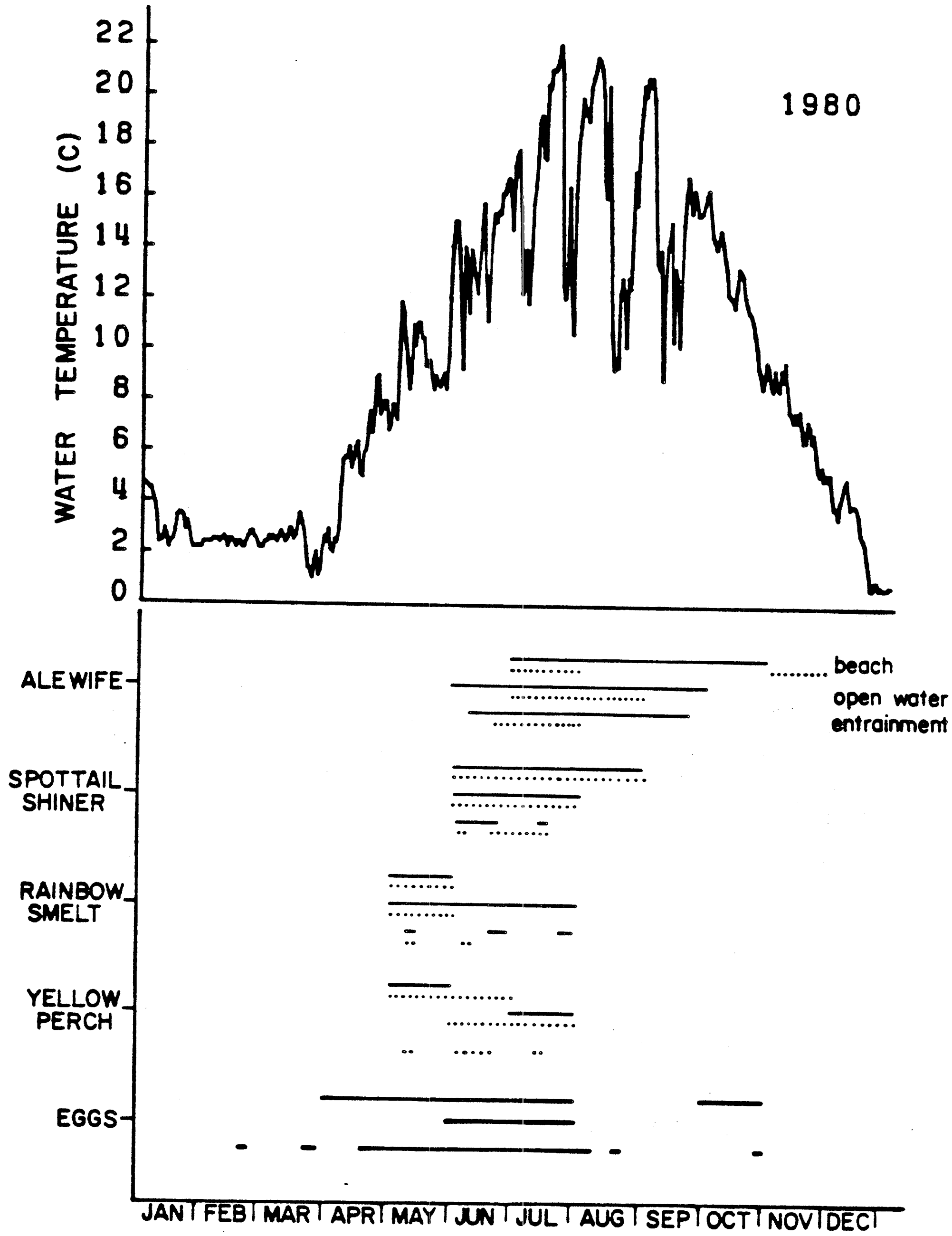


Figure 6. Seasonal occurrence of fish eggs (———) and yolk-sac larvae (··········) and post-yolk-sac larvae (——) of alewife, spottail shiner, rainbow smelt, and yellow perch in field and entrainment samples during 1980. Temperature profile represents daily water temperatures (6-m depth) recorded at St. Joseph, Mi., approximately 16 km north of the plant.

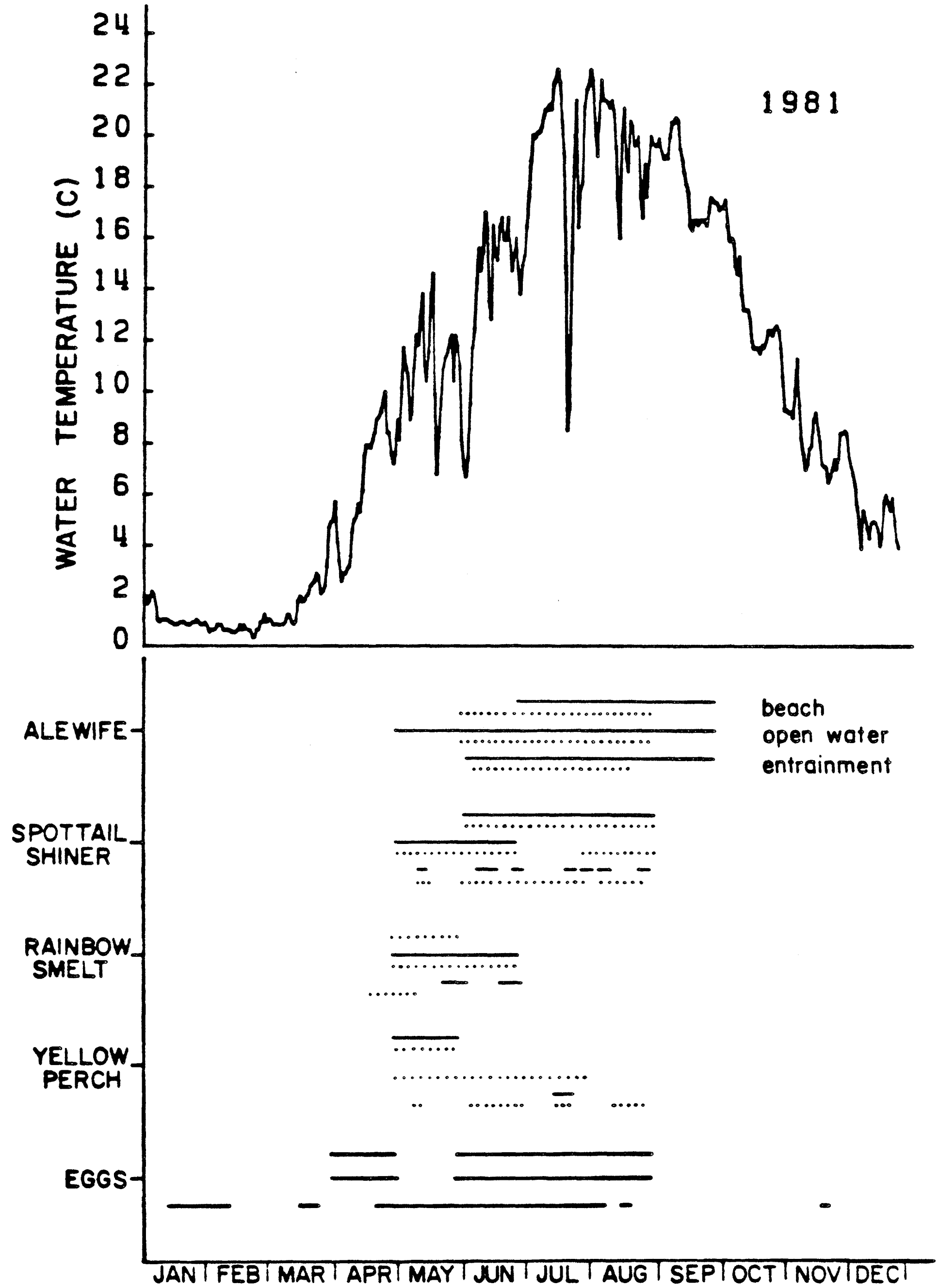


Figure 7. Seasonal occurrence of fish eggs (———) and yolk-sac larvae (·········) and post-yolk-sac larvae (——) of alewife, spottail shiner, rainbow smelt, and yellow perch in field and entrainment samples during 1981. Temperature profile represents daily water temperatures (6-m depth) recorded at St. Joseph, Mi., approximately 16 km north of the plant.

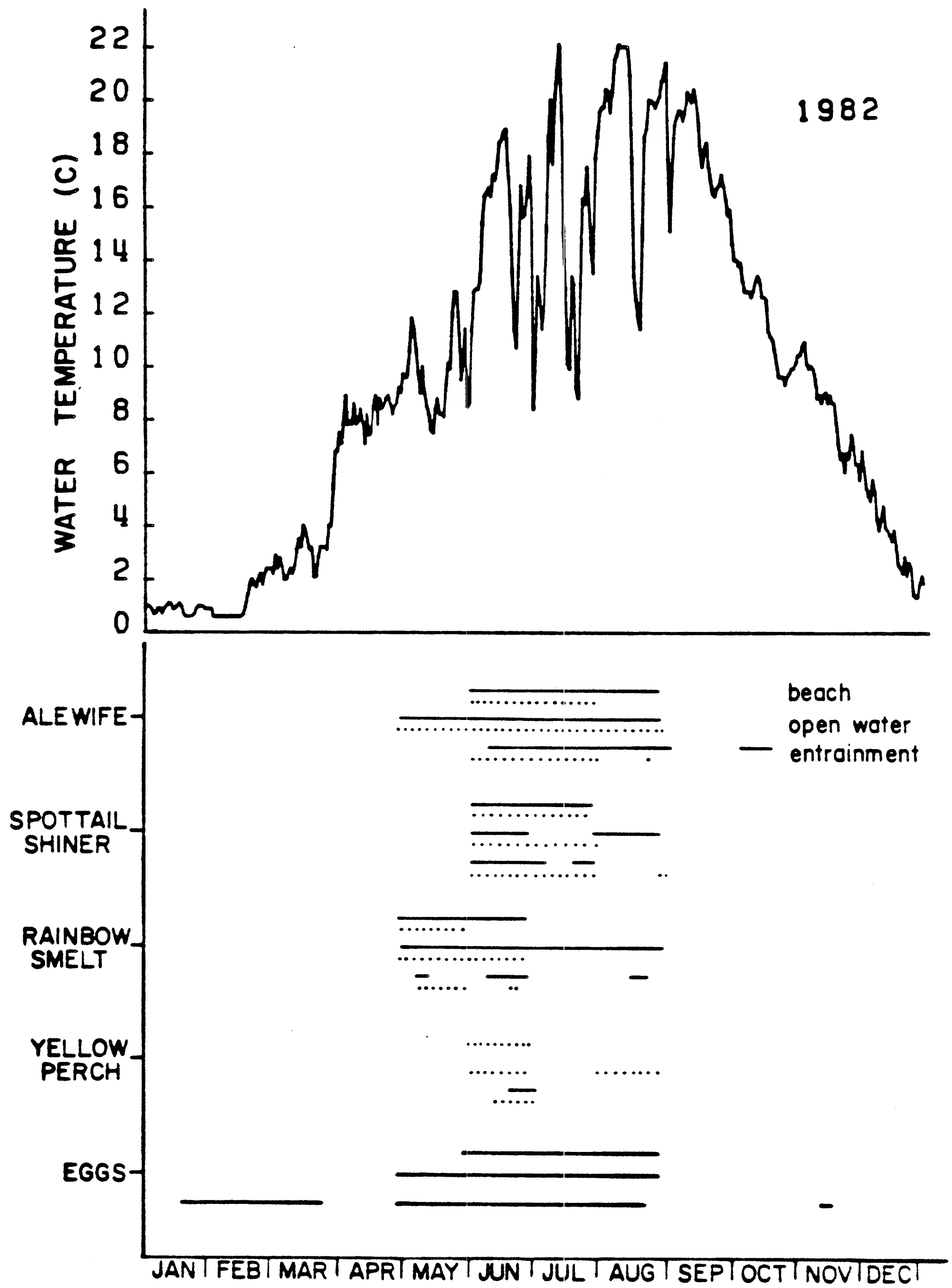


Figure 8. Seasonal occurrence of fish eggs (——) and yolk-sac larvae (········) and post-yolk-sac larvae (——) of alewife, spottail shiner, rainbow smelt, and yellow perch in field and entrainment samples during 1982. Temperature profile represents daily water temperatures (6-m depth) recorded at St. Joseph, Mi., approximately 16 km north of the plant.

Table 15. Estimates (in millions) of entrainment losses of fish larvae and fish eggs during 1980 at the D. C. Cook Plant, southeastern Lake Michigan. Calculations use actual reported flow rates of the circulating water system. No fish eggs or larvae were found in entrainment samples between 1 January and 31 January or between 4 November and 31 December 1980.

Taxon	1 Feb- 28 Feb	29 Feb- 31 Mar	1 Apr- 1 May	2 May- 1 Jun	2 Jun- 4 Jul	5 Jul- 1 Aug	2 Aug- 2 Sep	3 Sep- 2 Oct	3 Oct- 3 Nov	Total	% Total
Alewife					9.76	34.9	3.46	1.23		49.35	53.5
Spottail shiner					3.36	17.7				21.06	22.9
Rainbow smelt				10.8	1.04	0.114				11.954	13.0
Yellow perch				0.200	0.620	0.0771				0.8971	1.0
Slimy sculpin				0.244	0.309					0.553	0.6
Trout-perch					0.277		0.0908		0.118	0.4858	0.5
Ninespine stickleback					0.233	0.146				0.379	0.4
Common carp						0.0513				0.0513	<0.1
Unidentified sculpins				0.539	0.128					0.667	0.7
Unidentified minnows					0.161	0.051	0.0726			0.2846	0.3
Poor condition				0.770	1.45	4.18	0.0765			6.4765	7.0
Total larvae				12.553	17.338	57.2194	3.6999	1.23	0.118	92.1583	
Fish eggs	0.150	12.6	4.12	3.77	2600	711.	2.73.		0.322	3334.692	

Table 16. Estimates (in millions) of entrainment losses of fish larvae and fish eggs during 1981 at the D. C. Cook Plant, southeastern Lake Michigan. Calculations use actual reported flow rates of the circulating water system. No fish eggs or larvae were found in entrainment samples between 1 December and 31 December 1981.

Taxon	1 Jan-2 Feb	3 Feb-6 Mar	7 Mar-31 Mar	1 Apr-1 May	2 May-29 May	30 May-1 Jul	2 Jul-31 Jul	1 Aug-4 Sep	5 Sep-5 Oct	6 Oct-31 Oct	1 Nov-30 Nov	Total	% Total
Alewife						67.5	6.81	35.6	1.63			111.54	80.09
Spottail shiner					0.453	3.49	0.354	2.96				7.257	5.21
Rainbow smelt				0.0995	1.81	0.717						2.6265	1.89
Yellow perch					0.205	2.21	0.0151	0.0759				2.506	1.80
Slimy sculpin					0.743	0.259						1.002	0.72
Trout-perch						0.154	0.0214	0.364				0.5394	0.39
Quillback					0.534							0.534	0.38
Common carp								0.187				0.187	0.13
Ninespine stickleback								0.156				0.156	0.11
Johnny darter						0.153						0.153	0.11
Mottled sculpin						0.143						0.143	0.10
Unidentified sculpins					0.536	0.0593						0.5953	0.43
Unidentified minnows					0.0965			0.0749				0.1714	0.12
Poor condition					0.569	8.35	1.39	1.55				11.859	8.52
Total larvae				0.0995	4.9465	83.0353	8.5905	40.9678	1.63			139.2696	
Fish eggs	9.89	0.815	1.82	1.41	105.	470.	398.	8.83			0.175	995.94	

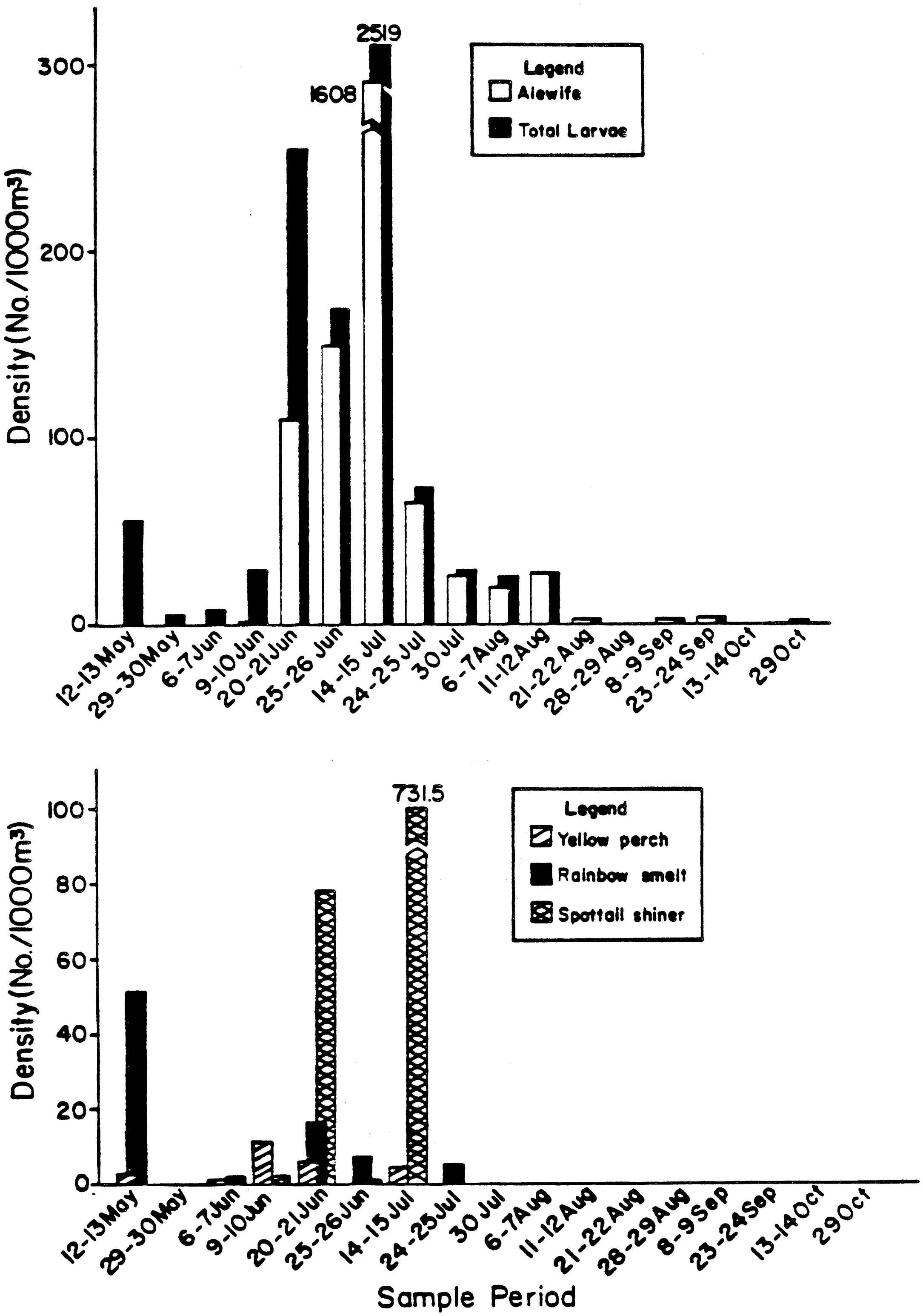


Figure 9. Density estimates of entrained fish larvae (no./1,000 m³) for alewife, spottail shiner, rainbow smelt, and yellow perch larvae, and fish eggs found in intake water used for condenser cooling at the D. C. Cook Plant, 1980.

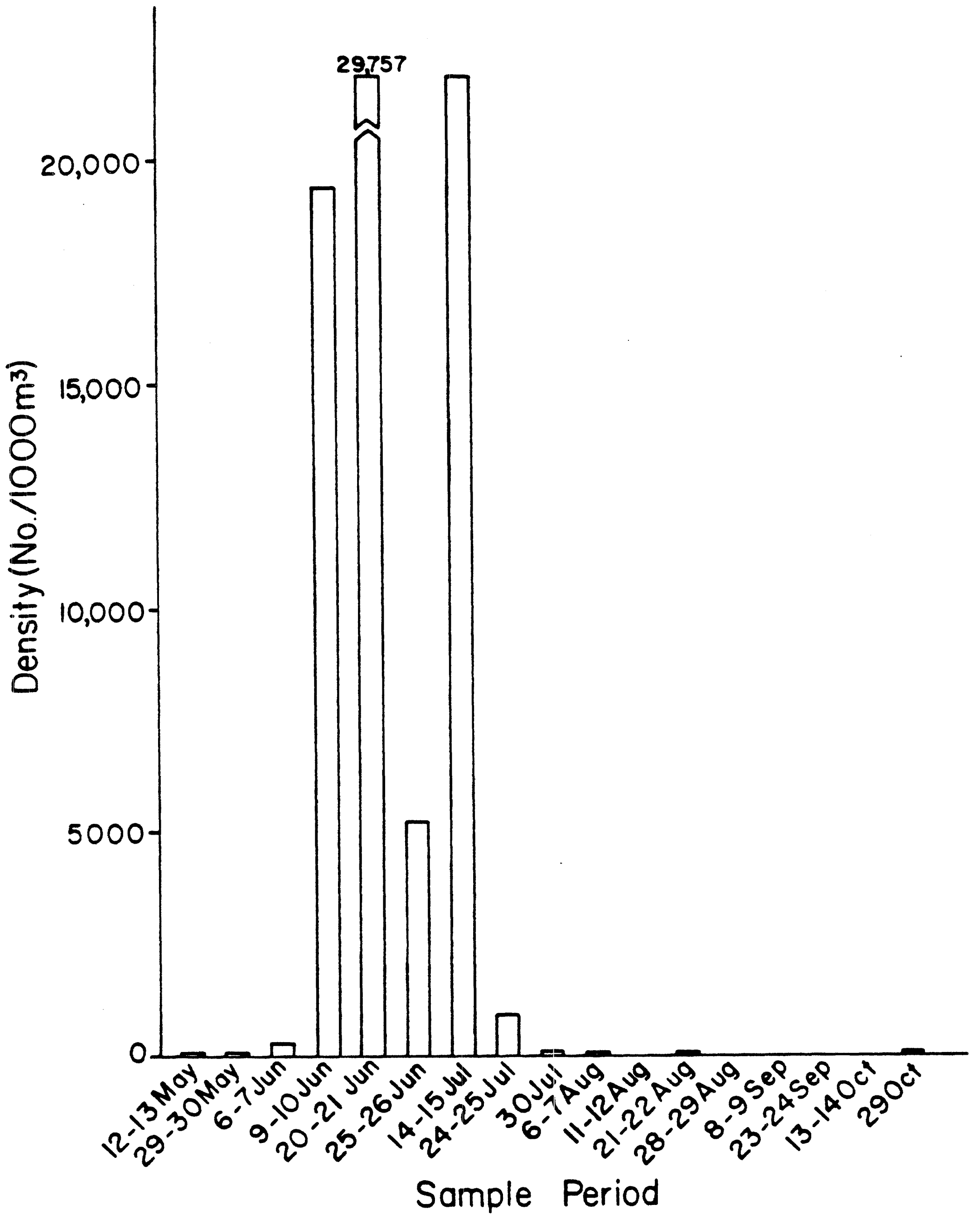


Figure 9. Continued.

Table 17. Estimates (in millions) of entrainment losses of fish larvae and fish eggs during 1982 at the D. C. Cook Plant, southeastern Lake Michigan. Calculations use actual reported flow rates of the circulating water system. No fish eggs or larvae were found in entrainment samples between 28 November and 31 December 1982.

Taxon	1 Jan- 1 Mar	2 Mar- 2 Apr	3 Apr- 3 May	4 May- 29 May	30 May- 3 Jul	4 Jul- 7 Aug	8 Aug- 29 Aug	30 Aug- 21 Sep	22 Sep- 27 Oct	28 Oct- 27 Nov	Total	% Total
Alewife					52.9271	37.6215	1.2844	0.0426	0.5494		92.4250	55.3
Spottail shiner					26.6123	1.5903		0.0271			28.2297	16.9
Rainbow smelt				13.5693	4.6602	0.0149	0.2789				18.5233	11.1
Yellow perch					4.9516		0.0184				4.9700	3.0
Trout-perch					0.0361		0.0632	0.0261	1.2495		1.3749	0.8
Johnny darter					0.4119	0.2357	0.0570				0.7046	0.4
Slimy sculpin				0.1870	0.3017						0.4887	0.3
Mottled sculpin				0.2234	0.2636						0.4870	0.3
Burbot					0.3428						0.3428	0.2
Ninespine stickleback						0.0112					0.0112	<0.1
Unidentified minnows					1.0280						1.0280	0.6
Unidentified sculpins				0.2142	0.3602						0.5744	0.3
Poor condition				2.9958	11.7472	2.9012	0.1116	0.0261	0.1639		17.9458	10.7
Total larvae				17.1897	103.6427	42.3748	1.8135	0.1219	1.9628		167.1054	
Fish eggs	102.24	0.74	1135.22	6.01	4960.08	800.77	0.04			0.16	7005.26	

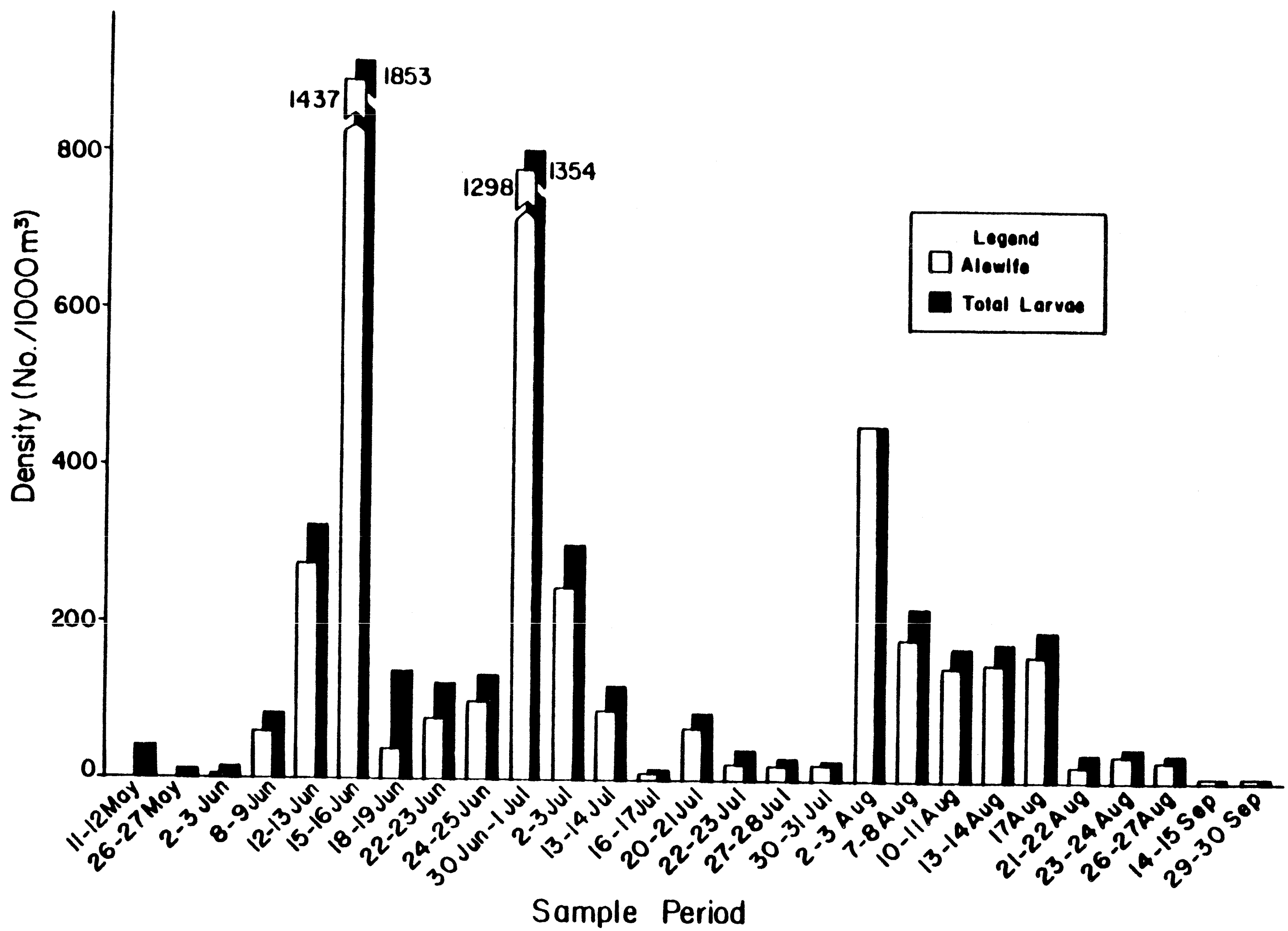
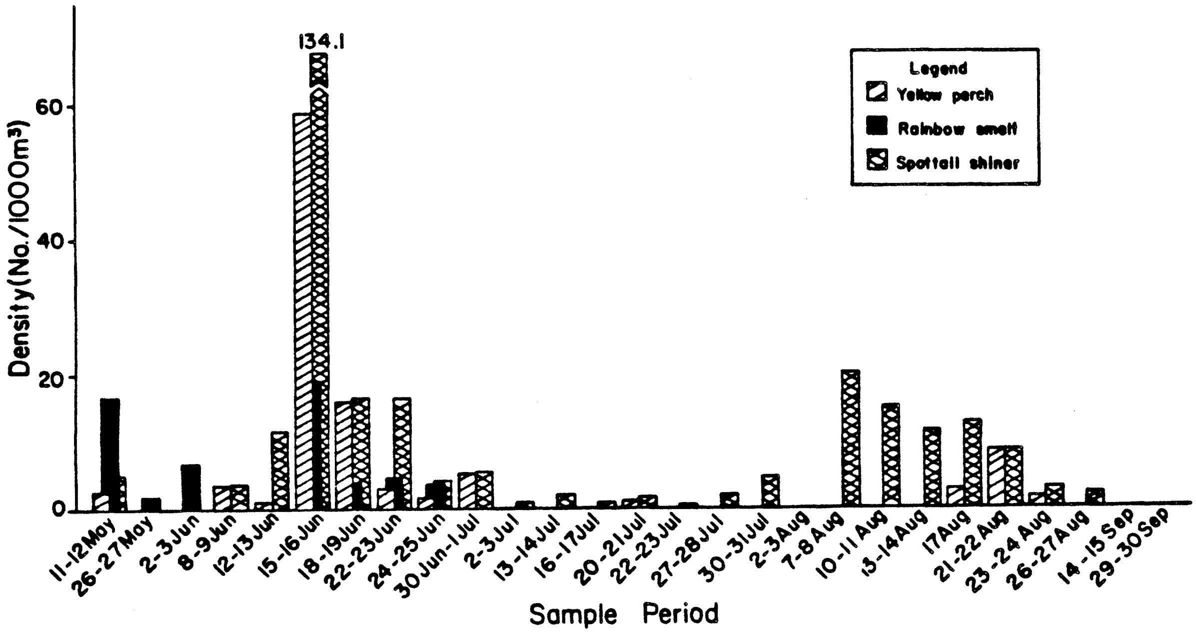


Figure 10. Density estimates of entrained fish larvae (no./1,000 m³) for alewife, spottail shiner, rainbow smelt, and yellow perch larvae, and fish eggs found in intake water used for condenser cooling at the D. C. Cook Plant, 1981.



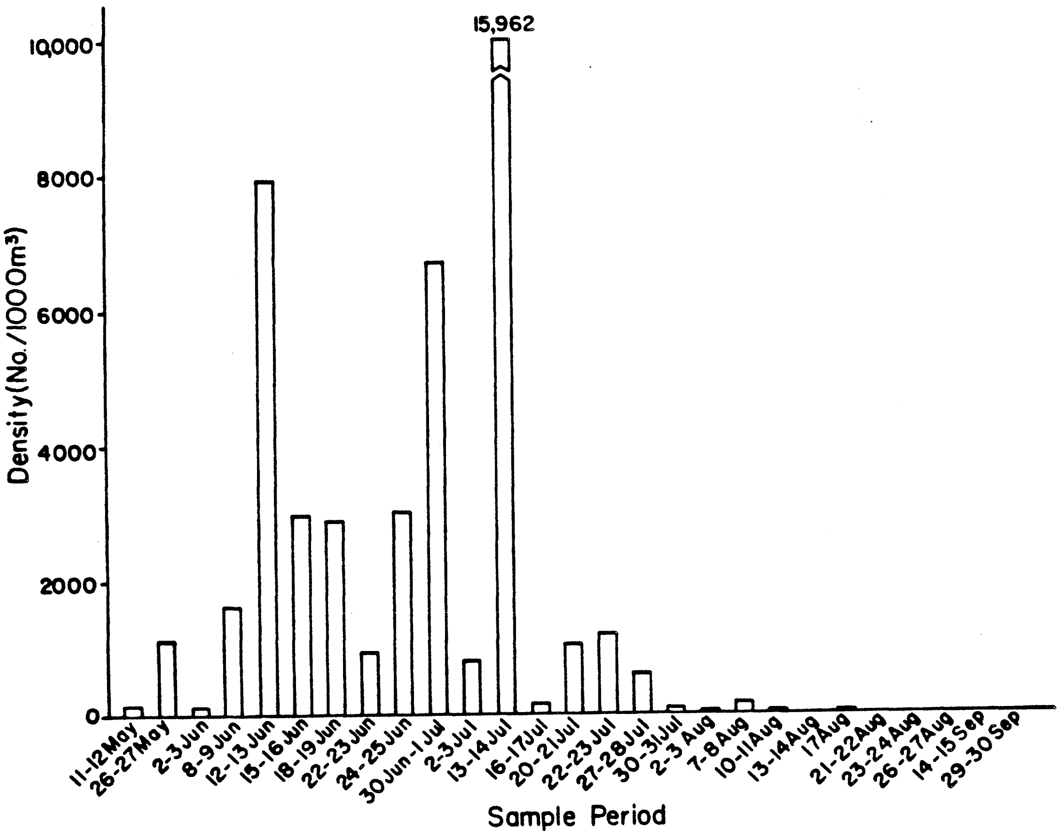


Figure 10. Continued.

The greatest mean densities in entrainment samples recorded over a 24-h sampling period (N = 16) in each year were: 1,831 larvae per 1,000 m^3 (8-9 July 1975), 1,039 larvae per 1,000 m^3 (20-21 July 1976), 379 larvae per 1,000 m^3 (21-23 July 1977), 140 larvae per 1,000 m^3 (25-26 July 1978), 892 larvae per 1,000 m^3 (26-27 July 1979), 1,608 larvae per 1,000 m^3 (14-15 July 1980), 1,437 larvae per 1,000 m^3 (15-16 June 1981), and 541 larvae per 1,000 m^3 (6-8 July 1982 - Tables 18-20). The thermal regime of Lake Michigan in the vicinity of the study area appears to be one factor that affects the magnitude of larval alewife abundance peaks. The lowest annual abundance peak (140 larvae per 1,000 m^3) during 8 years of entrainment sampling occurred in July 1978. Mean June and July temperatures in 1978 (13.7 °C and 14.1 °C, respectively) were 9% and 20% lower than the overall 1973-1982 mean temperatures for those months (Table 21). During 1975, the year with the greatest annual abundance peak (1,831 larvae per 1,000 m^3), mean June (16.2 °C) and July (19.5 °C) water temperatures were approximately 7% and 10% greater than the 10-yr overall mean June and July temperatures.

<u>Length-frequency distribution</u>-- The vast majority of entrained alewife have been yolk-sac larvae (<5 mm TL, Auer 1982). During 1975-1982 yolk-sac larvae accounted for between 61% (1979) and 94% (1975, 1980) of the total number of alewife entrained per year (Tables 22-24). This is not surprising, as increasing age brings increased mortality and probably an improved ability to avoid intake currents.

Alewife have an extended spawning period compared to many other species in our study area as is evidenced by the season of occurrence of yolk-sac larvae in entrainment samples. Yolk-sac larvae were first entrained in April (1977), May (1976, 1978), or June (1975, 1979-1982) and were present continuously until late July (1980) or August (all other years). The onset of spawning for alewife is closely related to water temperature (Threinen 1958, Cooper 1961). In 1976 and 1977 mean temperatures during March-May were higher than in any other year of entrainment sampling (Table 21). Accordingly, the earliest records of alewife yolk-sac larvae (10-11 May 1976 and 27-28 April 1977) occurred in those years (Bimber et al. 1984).

Although there are undoubtedly many factors that contribute to year-class strength in fishes, temperature is certainly an important one. Bimber et al. (1984) stated that the relative abundance of various length groups of alewife larvae entrained at the Cook Plant during 1975-1979 appeared to be related to water temperature, a pattern that seems to have held true during 1980-1982 as well. In 1980, a year of low overall abundance of alewife larvae, a number of upwellings occurred (Fig. 6) resulting in monthly mean temperatures from April to December that were consistently below the 10-yr average (Table 21).

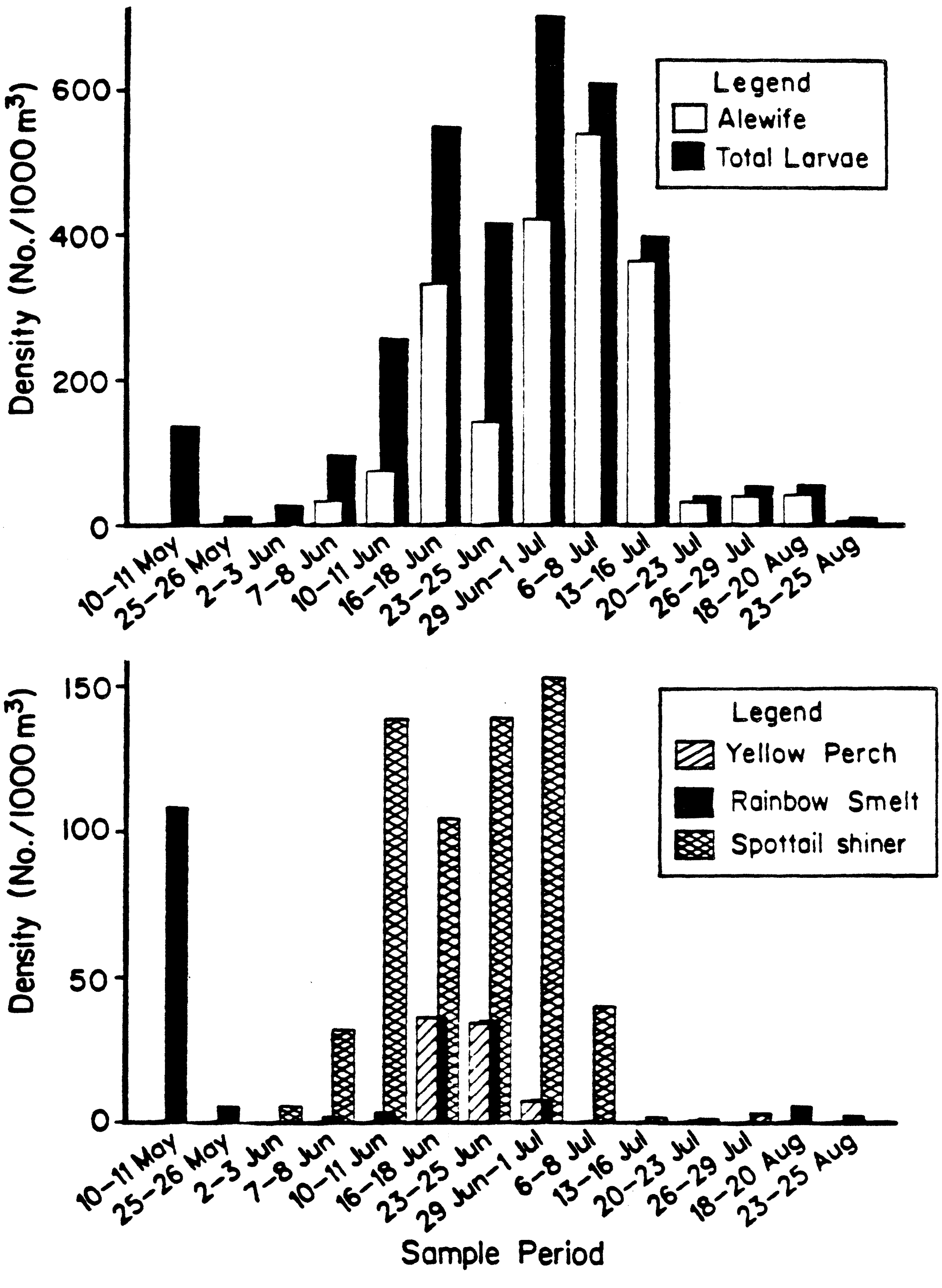


Figure 11. Density estimates of entrained fish larvae (no./1,000 m^3) for alewife, spottail shiner, rainbow smelt, and yellow perch larvae, and fish eggs found in intake water used for condenser cooling at the D. C. Cook Plant, 1982.

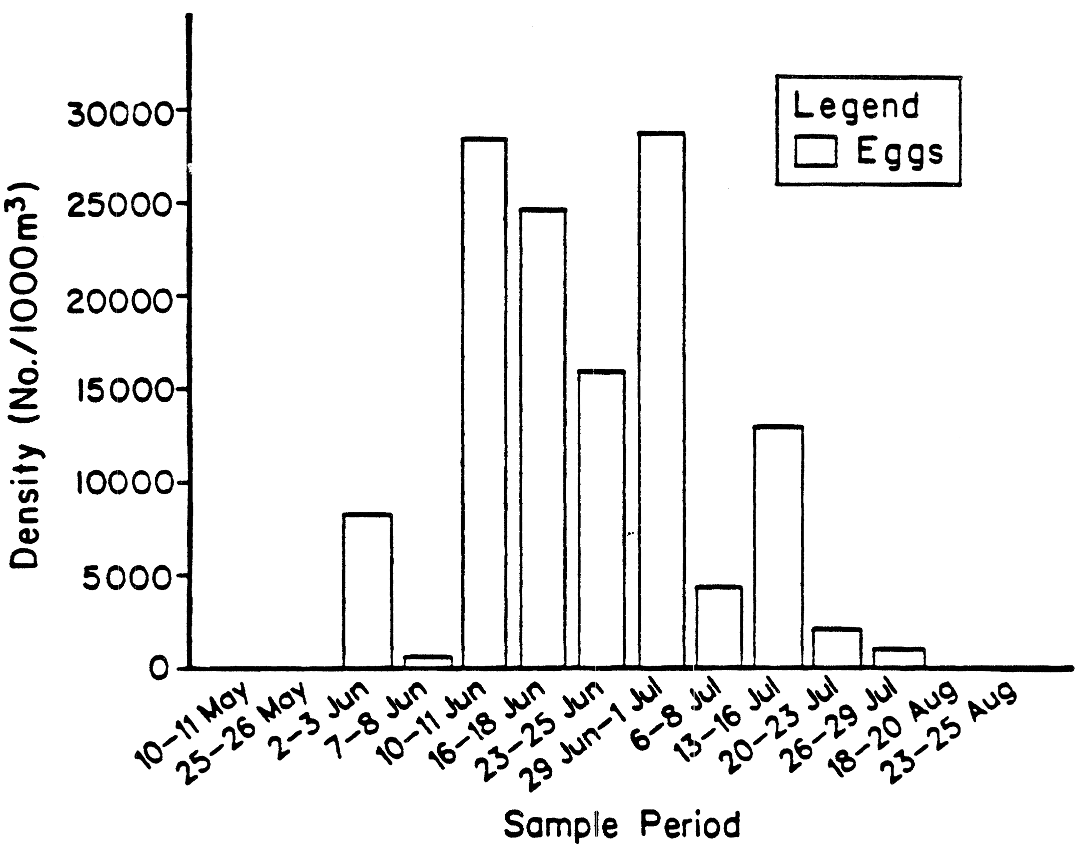


Figure 11. Continued.

Table 18. Mean densities (no./1,000 m³) for fish larvae and fish eggs entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1980. Data are summarized over diel periods: N1 (midnight-dawn), D1 (dawn-noon), D2 (noon-dusk), N2 (dusk-midnight). Blanks indicate zero densities. See Tables 1-2, 4 and Appendix 1 for sample sizes.

	Alewife				Spottail shiner				Rainbow smelt				Yellow perch				Total larvae				Fish eggs			
Date	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2
19-20 Feb																								4
26-27 Mar																					299		6	
21-23 Apr																					13	47	29	6
12-13 May									120	36	28	23			3		125	42	34	23			6	
29-30 May																	18		6		66	25		49
6-7 Jun					8					6				6			8	12		18	551	493	69	81
9-10 Jun	4							9					8		4	34	28		6	85	39435	19939	7136	11162
20-21 Jun	72	155	127	89	14		67	231	26	17	8	17		8		17	122	213	228	451	65998	7775	4516	40740
25-26 Jun	86	203	219	86	5				11	7	4	7					118	218	237	101	13115	3078	369	4433
14-15 Jul	1036	1061	288	4048	1638	18	18	1253						6		13	2951	1228	322	5575	63928	10144	3497	10078
24-25 Jul	109	29	19	103								18					125	29	19	121	3710	398	88	79
30 Jul	47	33		26													47	33		35	293	75	22	17
6-7 Aug	10	13	31	28													10	13	35	46		14	109	
11-12 Aug	46	31	18	12													46	31	18	12				
21-22 Aug	11																11						11	
8-9 Sep	13																13							
23-24 Sep				17																17				
29 Oct																				7	4			14

Table 19. Mean densities (no./1,000 m³) of fish larvae and fish eggs entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1981. Data are summarized over diel periods: N1 (midnight-dawn), D1 (dawn-noon), D2 (noon-dusk), N2 (dusk-midnight). Blanks indicate zero densities. See Tables 1-2, 5 and Appendix 2 for sample sizes.

Date	Alewife				Spottail shiner				Rainbow smelt				Yellow perch				Total larvae				Fish eggs			
	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2
12-13 Jan																					5			
27-28 Jan																					131	93	34	7
9-10 Feb																					11			5
16-17 Mar																					19		27	13
25-26 Mar																						6		
21-22 Apr									5								5					50	9	14
11-12 May					4	14	3		24	27	17		3	8			50	75	30	13	320	69	233	28
26-27 May									5		3						31	4	11	8	3291	403	193	445
2-3 Jun			4						5		7	16					10	3	15	33	273	155	82	79
8-9 Jun	14	53	42	128				15							3	12	28	53	67	197	4989	767	235	521
12-13 Jun	151	212	145	594	12	4	8	23					5				188	221	194	695	22850	3558	1693	3633
15-16 Jun	1000	1705	1282	1723	356	57	41	60	30		5	38	41	64	134	15	1714	2001	1783	1897	1896	891	2511	6504
18-19 Jun	79	29	16	39	5		11	51	15				29	25	3	6	215	74	39	227	8824	1257	505	949
22-23 Jun	95	54	30	138	27	15	10	15	13			6	8		5		166	80	58	197	2356	1018	228	265
24-25 Jul	66	95	122	116		8		9	5			8	7				100	116	137	187	8560	1134	438	1959
30 Jun-1 Jul	943	310	1639	2302	18		4						21				1069	332	1704	2310	17131	1856	2034	5781
2-3 Jul	367	190	91	334			4										514	194	116	378	1587	767	311	618
13-14 Jul	46	24	16	268	4	5											56	29	16	387	48545	6947	1927	6430
16-17 Jul		19	24			4												22	30	7	213	120	300	91
20-21 Jul	92	169	34		7								5				117	181	34	39	1220	2553	54	718
22-23 Jul	20	6		60	12		4	24									38	6	8	102	762	496	2127	1316
27-28 Jul	23	26	19	17	7												37	31	23	25	1499	353	548	83
30-31 Jul	22		43	21	11			8									32		43	29	231	53	29	93
2-3 Aug	193	465	149	995													193	469	149	995	23	5	8	19
7-8 Aug	171	164	161	225			80										176	173	270	272	76	211	435	61
10-11 Aug	145	105	78	251	16	5		39									166	111	82	319	49	18	55	15
13-14 Aug	115	114	250	126	46												197	114	259	134				
17 Aug	390	46	65	150	73	10		8								11	473	56	65	168	22	16	4	
21-22 Aug	38	11	24	21	32			9									89	11	24	30				
23-24 Aug	72	28	14	24	5			7								7	87	28	14	44				
26-27 Aug	54	21	13	20				10									58	21	17	41				
14-15 Sep	10	5		7													10	5		7				
29-30 Sep	10	5		8													10	5		8				
23-24 Nov																								5

Table 20. Mean densities (no./1,000 m³) of fish larvae and fish eggs entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1982. Data are summarized over diel periods: N1 (midnight-dawn), D1 (dawn-noon), D2 (noon-dusk), N2 (dusk-midnight). Blanks indicate zero densities. See Tables 1-2, 6 and Appendix 3 for sample sizes.

	Alewife				Spottail shiner				Rainbow smelt				Yellow perch				Total larvae				Fish eggs			
Date	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2	N1	D1	D2	N2
20-21 Jan																					63	37	46	186
8-9 Feb																					135	1020	1181	227
23-24 Feb																					13		1956	376
8-9 Mar																					15			
24-25 Mar																								10
26-27 Apr																					27023	93	525	283
10-11 May									138	65	56	175					161	102	58	222	10		13	27
25-26 May									9			14					20			27	119	22		26
2-3 Jun	6		3	8	18		6										49		8	49	16945	3507	1296	11469
7-8 Jun	44	53	18	19	15	10	3	101	5	3							82	86	33	182	443	418	212	288
10-11 Jun	105	10	17	170	264	3		288				14					402	23	23	579	28699	2494	3414	79077
16-18 Jun	486	186	160	460	290	6	5	105	84	11	10	39	63	5	56	24	1007	218	248	686	59332	2293	1270	32246
23-25 Jun	216	62	71	215	285	2	4	250	75	5	2	54	97	7	5	26	797	108	89	628	21962	1558	682	37867
29 Jun-1 Jul	371	168	161	987	348	20	4	241		2		29		7	6	18	899	209	194	1521	67202	3833	1541	42152
6-8 Jul	627	437	253	847	91	17	6	46									753	474	289	927	7699	843	557	8241
13-16 Jul	548	224	136	533	3		2	4									566	295	173	554	28609	1910	1416	17548
20-23 Jul	52	9	15	49				6				4					65	9	15	71	5790	301	159	1235
26-29 Jul	43	26	19	69	5	4		5									55	34	24	98	2746	318	165	381
18-20 Aug	106	28	9	26					22	2				3			136	36	11	39			1	
23-25 Aug	12	9	3							7	3						12	19	6	6		2		
1-3 Sep	6						4										6		4					
5-6 Oct			11														20		11	16				
19-20 Oct			5																5					
15-16 Nov																							5	

Table 21. Lake Michigan water temperatures (°C) measured at the St. Joseph Municipal Water Plant, 16 km north of the Cook Plant, 1973-1982; intake depth - 6 m. Data are monthly means of the daily average of maximum and minimum temperatures.

	Month											
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973	0.5	0.6	4.2	7.1	10.6	17.9	18.8	19.7	16.4	15.7	9.7	4.1
1974	1.2	1.1	3.7	7.5	11.3	14.9	17.2	16.5	16.2	13.3	9.2	3.0
1975	1.3	1.1	2.1	5.4	10.9	16.2	19.5	15.5	17.3	14.5	10.9	4.1
1976	1.1	2.1	5.4	9.6	11.0	16.7	19.2	20.5	18.0	14.6	8.3	2.0
1977	1.1	1.1	3.5	8.7	12.4	14.7	18.6	18.5	15.9	12.1	8.5	2.5
1978	1.7	1.4	1.5	5.6	10.2	13.7	14.1	17.9	18.4	14.0	10.1	3.1
1979	1.3	1.8	2.6	6.6	10.6	14.1	18.0	19.5	17.3	14.5	10.3	5.4
1980	3.0	2.4	2.4	5.9	9.8	14.3	16.7	16.4	15.2	12.4	7.2	2.6
1981	0.9	1.2	3.2	8.2	9.8	15.4	14.8	19.2	18.2	12.0	8.5	3.6
1982	1.2	0.7	1.8	6.3	10.7	13.7	18.5	20.1	18.5	14.4	8.9	5.8
1973-1982	1.3	1.4	3.0	7.1	10.7	15.1	17.6	18.4	17.2	13.8	9.2	3.6

Table 22. Length-frequency distribution of alewife larvae (sum of densities (no./1,000 m^3)) entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1980. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
9-10 Jun (16)					15																			
20-21 Jun (16)				1203	500	67																		
25-26 Jun (16)			298	1732	202	144																		
14-15 Jul (16)			1530	18392	5450	29						14	38	62	54		137		27					
24-25 Jul (14)				267	242	79	64	31			59	138									23			
30 Jul (16)				218						18	18		18	65		35			50					
6-7 Aug (16)							47	15		32									32	123		20	59	
11-12 Aug (16)					76	70				29	15		16	12					30	89	37	27	26	
21-22 Aug (16)								16	16	13														
8-9 Sep (15)										19										16		16		
23-24 Sep (16)																				23		45		

Table 23. Length-frequency distribution of alewife larvae (sum of densities (no./1,000 m³)) entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1981. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																						
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2-3 Jun (16)						14																		
8-9 Jun (16)		266	648	16	15																			
12-13 Jun (16)		577	2960	869																				
15-16 Jun (15)		6074	13779	1691	12																			
18-19 Jun (16)		45	288	226	69																			
22 23 Jun (16)		64	853	236		56	56																	
24-25 Jun (16)		287	935	299	43	16		15																
30 Jun-1 Jul (16)	49	6743	12564	1318	30		11				30		30											
2-3 Jul (16)	23	702	2841	298	51	18																		
13-14 Jul (16)		470	664	18	75	54	37	16		17							17				41			
16-17 Jul (16)		12	140						18															
20-21 Jul (15)		243	742	12										14										
22-23 Jul (15)		68	143	73				37	17															
27-28 Jul (16)			279	33	12	12																		
30-31 Jul (16)			104	28	62	31	15	13	18	28	41													
2-3 Aug (16)		690	4817	631	97	95	21	72	63	74	128	89	363	12	23							32		
7-8 Aug (16)		185	1048	455	353	365	85	45		20				85	38	17	50	81	58					
10-11 Aug (16)		14	377	122	175	184	35		98	20	49			49	49		72	261	92	285	159	158	26	93
13-14 Aug (16)		17	122	359	266	269	196	113	63	15				49	47	89	137	163	225	57	141	27	63	
17 Aug (16)			70	67	55	142	173	65	138	117	72	26		56	30		37	26	125	73	366	300	327	332
21-22 Aug (15)						16		16	19	16	49	16	54	57	44					48				
23-24 Aug (16)				30	30						28		71		34		17	40	30	56	21	35	35	121
26-27 Aug (15)			30	16	30							17			59	21	39	67	39	73		19		
14-15 Sep (16)													21									13	41	12
29-30 Sep (16)																				15			61	13

Table 24. Length-frequency distribution of alewife larvae (sum of densities (no./1,000 m³)) entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2-3 Jun (16)		42	24																					
7-8 Jun (16)		193	291	53																				
10-11 Jun (16)		275	878	45	12																			
16-18 Jun (31)		1988	6451	1699	21		19																	
23 25 Jun (31)	19	620	2241	863	389	85	124	49	19	25														
29 Jun-1 Jul (32)	32	3061	7500	1589	248	209	183	190	222	148	55						43							20
6-8 Jul (32)		3541	7301	1832	1297	1295	777	473	297	74	112	61	76	52	82	24					24			
13-16 Jul (36)	16	2248	3904	1741	530	384	764	474	494	606	481	305	488	246	106	139	96	25	25		44	22		
20-23 Jul (35)		80	339	100	31	73	35		31	16	18	31	58	25	11	172			55	10		10		40
26-29 Jul (32)		117	489	139	54	41	41	39			67	49		46		41	43			20	25		46	
18-20 Aug (32)									28	22	55		53	34	56	85	44	16	205	112	125	96	211	203
23-25 Aug (32)			21							15				17	25	37				25		14	38	
1-3 Sep (20)															25									
5-6 Oct (13)																					22			
19-20 Oct (16)																			20					

Spawning apparently began late and ended early in that year as yolk-sac larvae were only present from 20-21 June to 30 July, which represents the shortest season of occurrence for alewife yolk-sac larvae in 8 years of entrainment sampling at the D. C. Cook Plant. Only 6% of entrained alewives were post-yolk-sac larvae in 1980.

In comparison with 1980, the 1981 temperature profile was generally warmer and was much more stable, with only one major upwelling in July (Fig. 7). Yolk-sac larvae first appeared on 8-9 June and were present in entrainment samples until 26-27 August. The upwelling in July may have extended the duration of spawning. Heufelder et al. (1982) showed that upwelling events in Lake Michigan prolonged the period of occurrence of newly hatched larvae. A small percentage of the alewife larvae entrained in 1981 (14%) and 1982 (23%) were post-yolk-sac larvae.

Diel distribution-- Diel distribution of alewife larvae during 1980-1982 followed the same pattern established during 1975-1979 sampling, i.e., they were entrained in higher numbers at night than during the day (Tables 25-27). Examination of June-August entrainment samples during 1976-1982 via ANOVA showed that diel period was highly significant for alewife larvae densities (Table 9). The annual proportions of larvae entrained at night during 1980-1982 were 72%, 60%, and 74%, respectively. The dusk-midnight sampling period produced the greatest abundance of alewife larvae during 1980-1982. Alewife larvae entrained during dusk-midnight sampling represented 55% of the total number of alewife larvae entrained in 1980, 38% in 1981, and 42% in 1982.

Field Collections--

General trends-- Alewife was the dominant fish species in field larvae samples during all 10 years of our study. Occurrence of alewife larvae in the study area was distinctly seasonal, corresponding to the period of warmer water temperatures, chiefly June through August or September (Figs. 6-8). In the beach zone, alewife larvae first appeared in April (1978), June (1973-1977, 1981, 1982), or July (1979) and were present every month until August (1982), September (1973, 1976, 1981), October (1974, 1975, 1979), or November (1977, 1978, 1980).

In 1977 and 1980-1982 alewife larvae appeared in open water samples 1 month earlier than in beach zone samples. In 1978 alewife larvae were collected in the beach zone in April and then not again until June when they were present both at the beach and in open water. In all other years, first appearance at beach and open water stations occurred during the same month (Figs. 12-16;

Table 25. Length-frequency distributions (sum of densities in no./1,000 m³) by diel period for major species entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1980. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes: 457 (total), 117 (midnight-dawn), 115 (dawn-noon), 114 (noon-dusk), 111 (dusk-midnight).

Species/ diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	.7	18	19	20	21	22	23	24	25
Alewife																								
Midnight-dawn		368	3610	808	78	50	16	16	66	33	32	72	79	54		75		107	31	39	52	34		
Dawn-noon		411	4131	1159	238	24	17			16									55	21				
Noon-dusk		270	1913	337	42	37	29		13		33		26					32	55		11	11		
Dusk-midnight		779	12158	4181	31				32	43	87		34		35	62			110		45	40		
Spottail shiner																								
Midnight-dawn			727	4491	1441																			
Dawn-noon				70																				
Noon-dusk				248	93																			
Dusk-midnight			264	4640	1065																			
Rainbow smelt																								
Midnight-dawn				242	181	58	26								34	21	13	26	13			13		
Dawn-noon				62	86	18			67										15	14				
Noon-dusk				30	54	27		16												16	16			
Dusk-midnight					90													35		35		96		
Yellow perch																								
Midnight-dawn				30																				
Dawn-noon				23	54																			
Noon-dusk					14	11																		
Dusk-Midnight				76	123	53																		

Table 26. Length-frequency distributions (sum of densities in no./1,000 m³) by diel period for major species entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1981. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes: 648 (total), 163 (midnight-dawn), 160 (dawn-noon), 163 (noon-dusk), 162 (dusk-midnight).

Species/ diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Alewife																								
Midnight-dawn	33	2878	8088	1535	256	253	146	52	142	158	39	49	179	159	133	50	72	223	163	315	466	325	252	
Dawn-noon	16	2146	9593	2155	234	284	64	16	66	18	54	15	42	22	65	21	21	107	120		46	31	64	
Noon-dusk		3467	8810	1308	339	354	188	104	63	32	95	46		40	47	56	187	126	221	84	126	27	27	
Dusk-midnight	33	7966	16913	1799	546	381	231	220	163	99	209	38	318	101	79		89	182	65	208	90	201	210	
Spottail shiner																								
Midnight-dawn			252	1534	630		17	17			24		19											
Dawn-noon			55	367	40		19																	
Noon-dusk		17	74	246	205	33			35															
Dusk-midnight				732	269	35		31	31															
Rainbow smelt																								
Midnight-dawn			12	50	43	18				18			20	20	19		73	15	20	21	22	21	19	
Dawn-noon				61	46																			
Noon-dusk			11	22	33	10						14	14						14					
Dusk-midnight								23	36				32	29				33	89				29	
Yellow perch																								
Midnight-dawn				174	213	40		22		22														
Dawn-noon			15	200	138	31																		
Noon-dusk		10	26	198	209																			
Dusk-Midnight				27	129		42																	

Table 27. Length-frequency distributions (sum of densities in no./1,000 m³) by diel period for major species entrained at the D. C. Cook Plant, southeastern Lake Michigan, 1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes: 618 (total), 157 (midnight-dawn), 155 (dawn-noon), 151 (noon-dusk), 155 (dusk-midnight).

Species/ diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Alewife																								
Midnight-dawn		2718	8483	2481	885	635	963	521	497	404	366	250	277	249	147	334	137	25	157	103	193	102	256	192
Dawn-noon	16	2086	4831	1047	379	342	225	87		71	34	35	18	15	14	37	16	16	50	34		30	15	31
Noon-dusk	13	1398	2939	1011	318	258	95	72	80	70	55	15	121		47		12		39		22			
Dusk-midnight	51	5677	12795	3348	950	729	550	458	416	259	214	106	241	114	65	107	49		49	20	25		24	20
Spottail shiner																								
Midnight-dawn		118	1409	4813	2816	112	70		27															
Dawn-noon			83	253	101																			
Noon-dusk			12	138	59																			
Dusk-midnight			652	4323	1552	273	20																	
Rainbow smelt																								
Midnight-dawn			44	374	220				17		56	39	64	90	76	231	35	267	242	23	20	145		103
Dawn-noon				142	116						34	16	13	14	15	18	15		28				43	27
Noon-dusk			9	155	59					11			12		[illegible]	12	10						25	
Dusk-midnight				351	376	27		51				58		121	25	152	99	51	194	89	29	54	51	85
Yellow perch																								
Midnight-dawn			44	699	484	24		28																
Dawn-noon			13		121		27		13															
Noon-dusk				98	288	86																		
Dusk-Midnight				142	322	76																		

Tables 28-37). Month of peak abundance in the beach zone was July in 7 of the 10 years of our study, August in 2 years, and June in 1 year.

In 5 of the 10 years of our study (1975, 1977-1980) peak abundances of alewife larvae at beach and open water stations occurred during the same month. Abundance peaks occurred earlier in open water than in the beach zone during 4 years (1973, 1974, 1981, 1982). In 1976 peak abundance occurred in June in the beach zone and in July at open water stations. June, July, and August samples combined accounted for 90-99+% of all alewife larvae collected in every year except 1979, when June-August samples provided only 79% of the annual alewife catch. In all but 1 year (1974) annual mean densities for alewife larvae were higher in the beach zone than in open water. Mean densities (no. per 1,000 m^3) of alewife larvae in the beach zone for June-August samples combined during 1973-1982 were: 6,757, 793, 1,842, 2,497, 2,740, 1,132, 870, 3,124, 400, and 2,255, respectively (N usually = 36). Mean densities (no. larvae per 1,000 m^3) in the open water zone for June-August samples combined during 1973-1982 were respectively: 1,099, 1,603, 689, 550, 129, 39, 572, 255, 138, and 439 (N usually = 180).

Mean densities differed significantly among years and among months at both beach and open water stations (ANOVA, $p < 0.0001$ at both sets of stations for both year and month). Mean abundance did not differ significantly between Warren Dunes and the Cook Plant (ANOVA: beach - $p = 0.3775$; openwater - $p = 0.5758$), implying no detectable plant effect.

Depth distribution-- During 1980-1982 abundance of larval alewives at various depth contours followed the same pattern that was established during 1973-1979 sampling, i.e., alewife abundance generally declined with increasing bottom depth (Figs. 12-16, Table 38). Mean densities differed significantly among station depths (ANOVA; $p < 0.0001$). On a yearly basis, alewife larvae abundance correlated more consistently with bottom depth than with any other parameter. Densities at beach and 6-m stations exceeded densities at 9-m stations in all years (1973-1982) and in all months except May 1981, when the only alewife larvae collected were at Cook station D (9 m) during night sampling. Alewife larvae were scarce at 21-m stations compared to high inshore abundances, presumably because spawning and hatching were concentrated inshore. Water temperature was shown to be an important correlate of larval fish abundance during 1973-1979 sampling, with greatest abundances usually occurring in the zone (beach or openwater) where water temperatures were the highest (Bimber et al. 1984). This held true in July and August during 1980-1982 when temperatures were higher and larval alewife

Table 28. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1973. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parenthesis.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
13,18 Apr (12)																								
17-18 May (12)																								
19-20 Jun (12)		48	739	214	286	787	1096	810	95															
19-20 Jul (12)		238	1930	2288	524	71	143	429	858	882	810	357	501	858	739	310	214	24	48			24		24
8-9 Aug (12)				99	73	24	182	227	775	997	1175	538	294	169	165	125	24						53	
6-7 Sep (12)																			24					
10 Oct (12)																								
14-15 Nov (10)																								
OPEN WATER																								
26,28-29 Apr (32)																								
15 May (32)																								
18-19 Jun (36)		19	464	846	605	271	240	82	22															
16-17 Jul (36)			41	205	88	76	82	55	40	24	5	4	5	10	4	4		4	10	18	9	5	2	
21-22 Aug (36)										11					6	4			7	6	4		8	8
17-18 Sep (32)																								
26-27 Oct (36)																								

Table 29. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1974. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL. Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
18-20 Apr (12)																								
15-17 May (12)																								
11-12 Jun (12)			432	1360	192																			
16-17 Jul (12)			68	330	64	24			26	26				10	70	154	106	32	15		10			
19 Aug (12)			28						44		9	23				12	35	12						
9 Sep (12)									10	10	9	10	39	70	39	69	28	20	38	11	48	57	157	79
8-9 Oct (12)															16		12		28	28		16		
26 Nov (12)																								
OPEN WATER																								
16-17 Apr (36)																								
13-14 May (36)																								
11-12 Jun (36)		19	257	1691	608	11																		
7-9 Jul (36)		15	101		1555	581	9	20	16	4	33	47	4											
19-20 Aug (36)			2	8	17	47	39	33	36	11	8	7	3	5	5	5	2	3	3	6	2	2		2
9-10 Sep (36)				1	1							1	6	2	6	10	3	2	8	6	7	4	6	3
7-8 Oct (36)																				2		1		

Table 30. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1975. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
13-14 May (12)																								
23-24 Jun (12)		19	370	1554	380	105	33	34	21	9														
16 Jul (12)		53	903	719	27	9	8		35	26	52	23	8	17		12	34	23	34	27	37	35	26	29
11-13 Aug (12)				10	17		47	60	38	69	148	205	371	272	176	81	61	61	15		8	13	10	10
9-10 Sep (12)																		10	10	32	19	10		
13-14 Oct (12)																				12	12	75	47	23
4 Nov (12)																								
OPEN WATER																								
14,16 Apr (60)																								
13-15 May (60)																								
10-11 Jun (60)			18	170	25	3	1																	
15-16 Jul (60)	<1	32	682	847	97	12	8	12	7	7	4	1	1	3	2			1	1		1	1	1	1
12-13 Aug (60)				2	1	1	<1	3	1	3	6	9	10	14	18	16	22	20	23	16	12	5	1	1
10-11 Sep (60)									<1	<1		<1	<1			1	3	2	3	2	1			
14,16-17 Oct (56)																				1				

Table 31. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
12-13 Apr (12)																								
10 May (12)																								
14 Jun (12)		39	2341	3202	651	69			10															
13 Jul (12)			57	297	45	47					11	47	88	123	24			72	100	32	24		12	13
9-10 Aug (12)			10		9										9		10		10	10	19	27	47	37
13-14 Sep (12)																		25	10					
11-12 Oct (12)																								
8 Nov (12)																								
OPEN WATER																								
13-14 Apr (50)																								
12-14 May (60)																								
21-22 Jun (51)		2	18	37	24	7	3	1	3	1	2		1	<1										
13-15,17 Jul (60)		4	121	317	184	166	86	31	14	13	14	14	12	25	27	44	56	41	15	10	7	3	2	4
10-11 Aug (60)				<1	1	1	1	2	3	8	16	13	14	14	12	7	7	4	4	1	2	<1	<1	1
14-15 Sep (44)																1	2	1	1	1	2		1	1
19 Oct (35)																								

Table 32. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1977. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11 Apr (12)																								
17 May (12)																								
13 Jun (12)			41	30																				
12 Jul (12)		21	183	572	1078	340	87	11	105	75	69	47	47	11	346	147	211	397	766	884	592	727	509	434
9-10 Aug (12)							13			27	26		13	29	13	26	29	26	41	13	28	59	24	122
12 Sep (12)												11			13	11	37	22	125	142	62	113	97	94
10 Oct (12)																		32	43		9	9		
8 Nov (12)																			11		21	21		
OPEN WATER																								
17 Apr (44)																								
17-19 May (42)				1																				
15-16 Jun (60)		7	9	17	4	2	2	2	1															
12,27-28 Jul (60)			12	55	63	36	19	7	5	1	<1	<1	1		<1		<1	1	1	2	1	1	1	<1
9-11 Aug (60)		1	10	38	34	7	5	<1	2	2	4	3		6	4	3	3	3	2	2	2	1		<1
13,15 Sep (52)															<1									

Table 33. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1978. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
10,12 Apr (12)		10																						
8 May (12)																								
13-14 Jun (12)		55	82	18																				
10-11 Jul (12)		79	387	643	112	35	23	110	77								17							
8-9 Aug (12)		12	120	83			20		10	46	157	148	154	248	213	59	29		42	95	36	155	77	55
11 Sep (12)																		10						
9 Oct (12)																26	6	9			9	22		
15-16 Nov (12)																							10	
OPEN WATER																								
11,27-28 Apr (59)																								
10 May (60)																								
14,22-23 Jun (60)		1	31	17	1	1																		
11-12 Jul (60)			2	3					1															
9,29-30 Aug (60)		1	22	18	1	1				1	2	5	2	2	1			<1		<1	<1	1		
12,28 Sep (44)				1							1	1			1	1	1			2	1	3	2	2

Table 34. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11-12 Apr (12)																								
7 May (12)																								
11-12 Jun (12)																								
11 Jul (12)		17	545	700	330	100	49	75	16	54	94	153	64	28										
7-8 Aug (12)			61	170		33	21	24			8	12	12							24				20
12 Sep (12)																	57	63	119	212	427	473	92	290
8,10 Oct (12)																53	24	99	96	235	169	241	181	48
14 Nov (12)																								
OPEN WATER																								
10-11,19 Apr (60)																								
8-10 May (60)																								
12-13 Jun (60)																								
10-11 Jul (60)			743	624	27	12	12	13	13	16	18	28	15	1	1				2					
8,16-17 Aug (60)		6	33	26	10	15	13	16	14	8	10	3	2	4	6	1	1	2	1	4	2	3	3	10
11-12 Sep (56)									1								1		3	1				

Table 35. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1980. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
7 Apr (12)																								
14 May (12)																								
9 Jun (12)																								
7-8 Jul (12)		36	1015	7065	966	12	47		14	14			12	14	30	50	30		7					
12 Aug (12)						6											17		5	6		14	13	
8 Sep (12)									12									12			10			
13 Oct (12)																			17			10		
12-13 Nov (12)				10																				
OPEN WATER																								
8,16-17 Apr (60)																								
13-15 May (60)																								
10-11 Jun (60)					<1	1	<1																	
8-9 Jul (60)		2	48	220	191	87	58	39	23	13	6	2	4	5	6	6	4	2	<1		<1			
12-13 Aug (60)			7	12	12	6	3	1	1	<1	1	1	1	1	1		2		1	2	1	1	1	1
8-10 Sep (60)													1	<1		1	1	4	2	1	<1			

Table 36. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1981. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
6 Apr (12)																								
14 May (12)																								
8-9 Jun (12)		36	16	40																				
8-9 Jul (12)		77	258	76								9	10		15	10		43						
10 Aug (12)				15	23	8	15	10	34	31	41	10	19		20	38	20	10		19	19	29	104	150
15 Sep (12)																	11	18	11	76	47	53	30	61
12 Oct (12)																								
9 Nov (12)																								
OPEN WATER																								
8,15-16 Apr (60)																								
12-13 May (60)						1																		
9-11 Jun (60)		<1	154	48	1		<1																	
6-7 Jul (60)			15	18	2		<1		1				1		<1									
12-13 Aug (60)		1	12	26	19	14	13	9	4	4	6	5	4	3	10	10	16	7	3	4	1	1	<1	1
18,22-23 Sep (60)																	<1		2	2	2	3	1	1

Table 37. Length-frequency distribution of alewife larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
12-13 May (12)																								
16-17 Jun (12)		6	211	517	20																			
19 Jul (12)		40	91	48	26	26	8				10	40	114	198	395	438	453	626	950	907	716	426	258	153
10 Aug (12)					9	9						43		14	6			5						
13 Sep (12)																								
11-12 Oct (12)																								
9-10 Nov (12)																								
OPEN WATER																								
13-14 Apr (60)																								
10-11 May (60)				3	11				1															
16-17 Jun (44)		41	737	374	4				<1	1	<1	<1	<1	1	1		<1							
20-21 Jul (44)		9	61	26	6	10	4	6	4	6	4	9	15	22	25	27	21	20	24	28	14	10	5	2
10 Aug (44)			1	3	8	12	10	4	6	8	8	6	9	20	30	39	40	27	17	13	7	5	3	2

abundance was greater in the beach zone than in open water. However, during the early part of the season (May-June) no such pattern could be discerned.

Table 38. Mean densities (no. per 1,000 m^3) of alewife larvae by depth contour (pooled over strata, month, and diel period) during 1980-1982. Values given represent June, July, and August samples combined. (No 21-m stations were sampled in 1982.) N = sample size.

Bottom Contour (N)	Year		
	1980	1981	1982
1 m (36)	3,124	401	2,255
6 m (72)	387	233	768
9 m (60)	214	132	396
21 m (48)	115	4	ND

<u>Diel distribution</u>-- There was not a consistent pattern of diel distribution for alewife larvae in the beach zone. During 4 years (1973, 1977, 1981, 1982) more larval alewives were caught during the day than at night at beach stations and during 6 years (1974-1976, 1978-1980) more were caught during night sampling. The diel factor was not significant for larval alewife densities in the beach zone over the 10-yr study period (ANOVA; $p = 0.1195$). Diel period was shown to be significant, however, when examined by month ($p = 0.0007$). Sampling in the beach zone produced more alewife larvae at night than during the day in June and July, but in August alewives were most abundant during the day.

In contrast, there was a consistent change in abundance of alewife larvae with diel period in the open water zone. Larval alewife densities were greater at night than during the day throughout the season in nearly every year (Tables 39-41). Only in June and July 1977 and 1980 and August 1978 did daytime catches exceed night catches. In two of those instances (July 1977 and August 1978) the reversal probably occurred because night samples were taken more than 2 wk later than day samples, on dates outside the period of peak alewife abundance. The Diel factor was shown to be highly significant ($p < 0.0001$) for larval alewife densities in the open water zone.

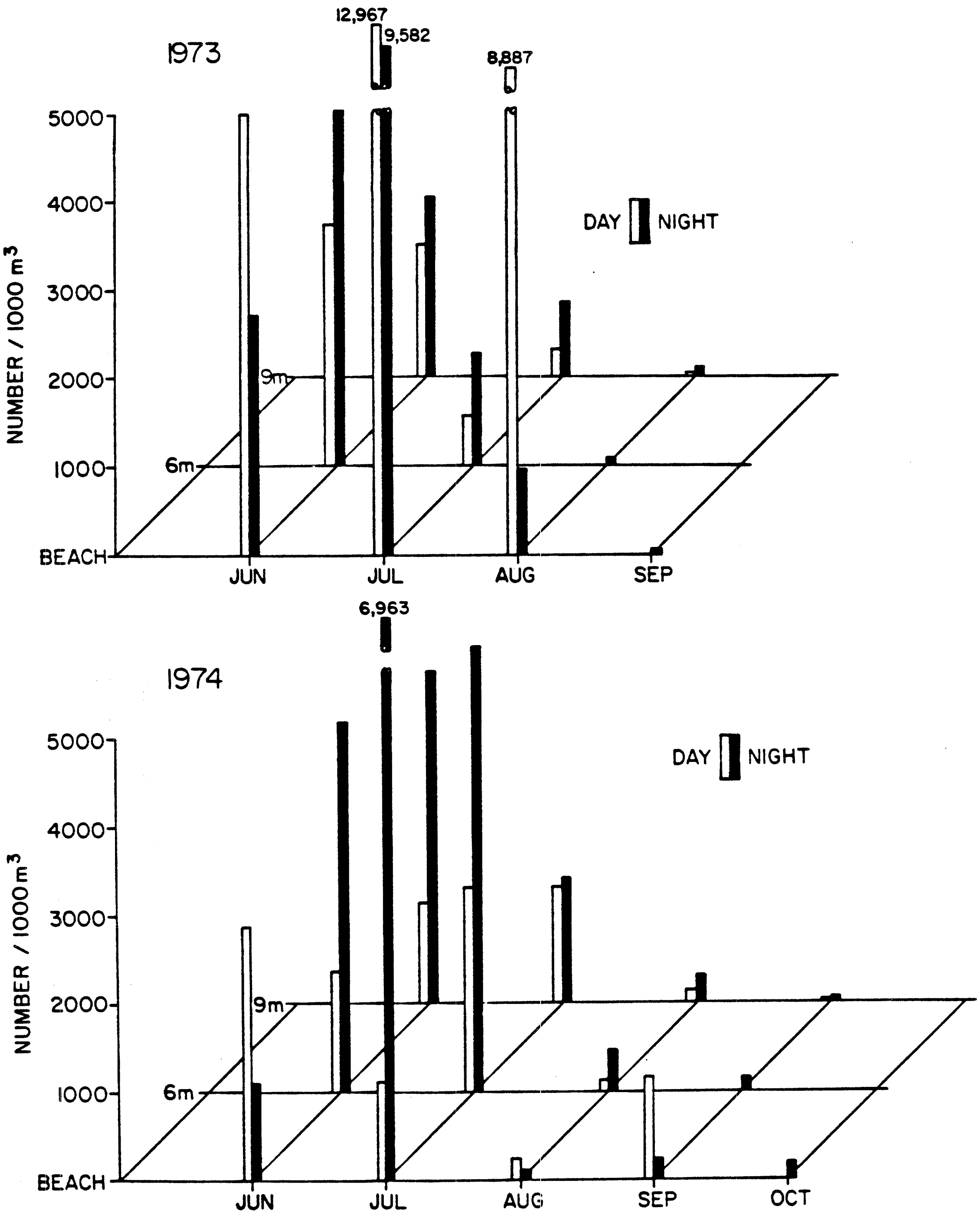


Figure 12. Mean densities (no./1,000 m³) of alewife larvae by depth contour, 1973 and 1974. Beach = stations A, B, and F; 6-m contour = stations C, G, and R; 9-m contour = stations D and H. (No 21-m stations were sampled in 1973 or 1974.)

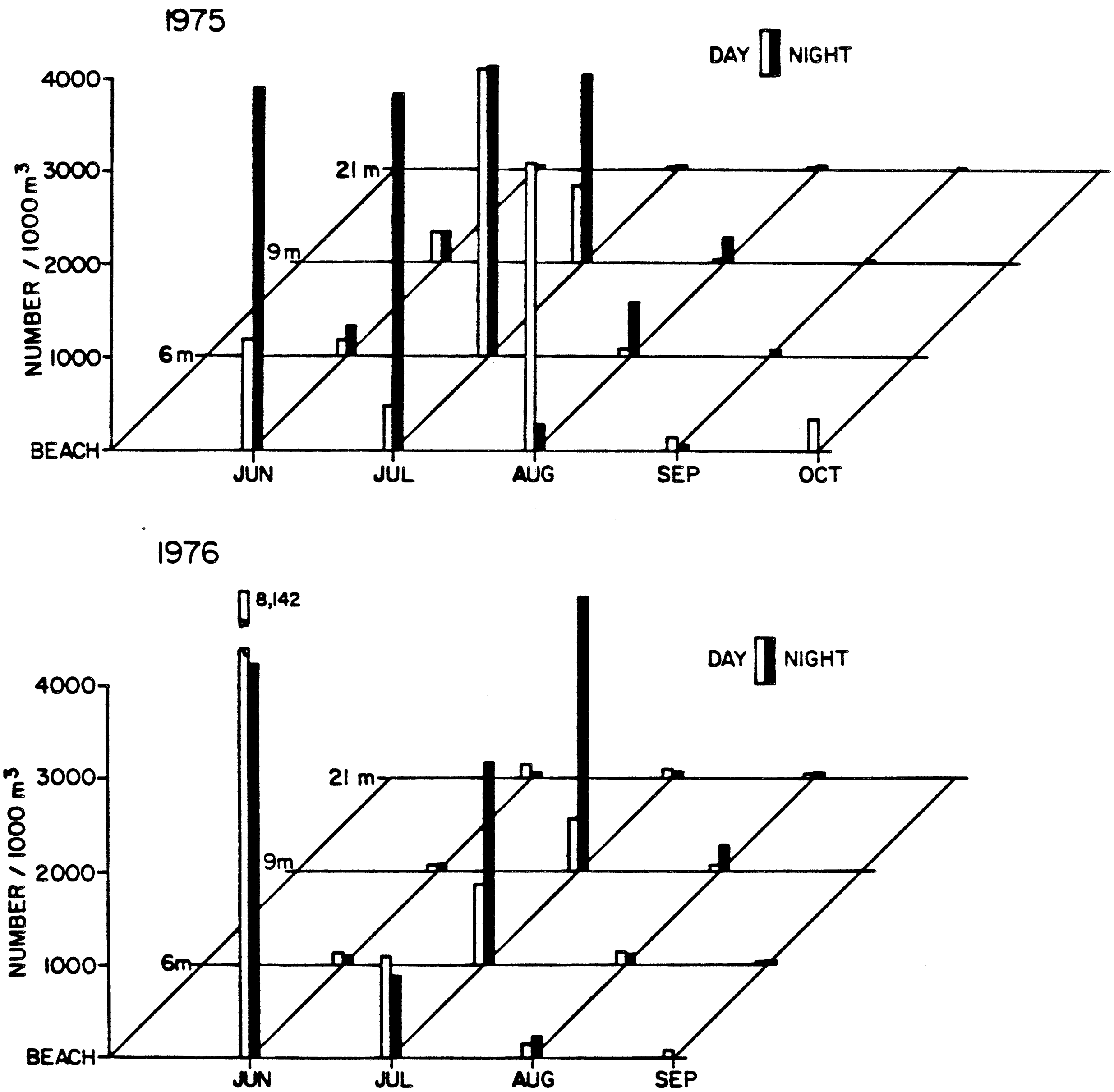


Figure 13. Mean densities (no./1,000 m³) of alewife larvae by depth contour, 1975 and 1976. Beach = stations A, B, and F; 6-m contour = stations C, G, and R; 9-m contour = stations D and H; 21-m contour = stations E and W.

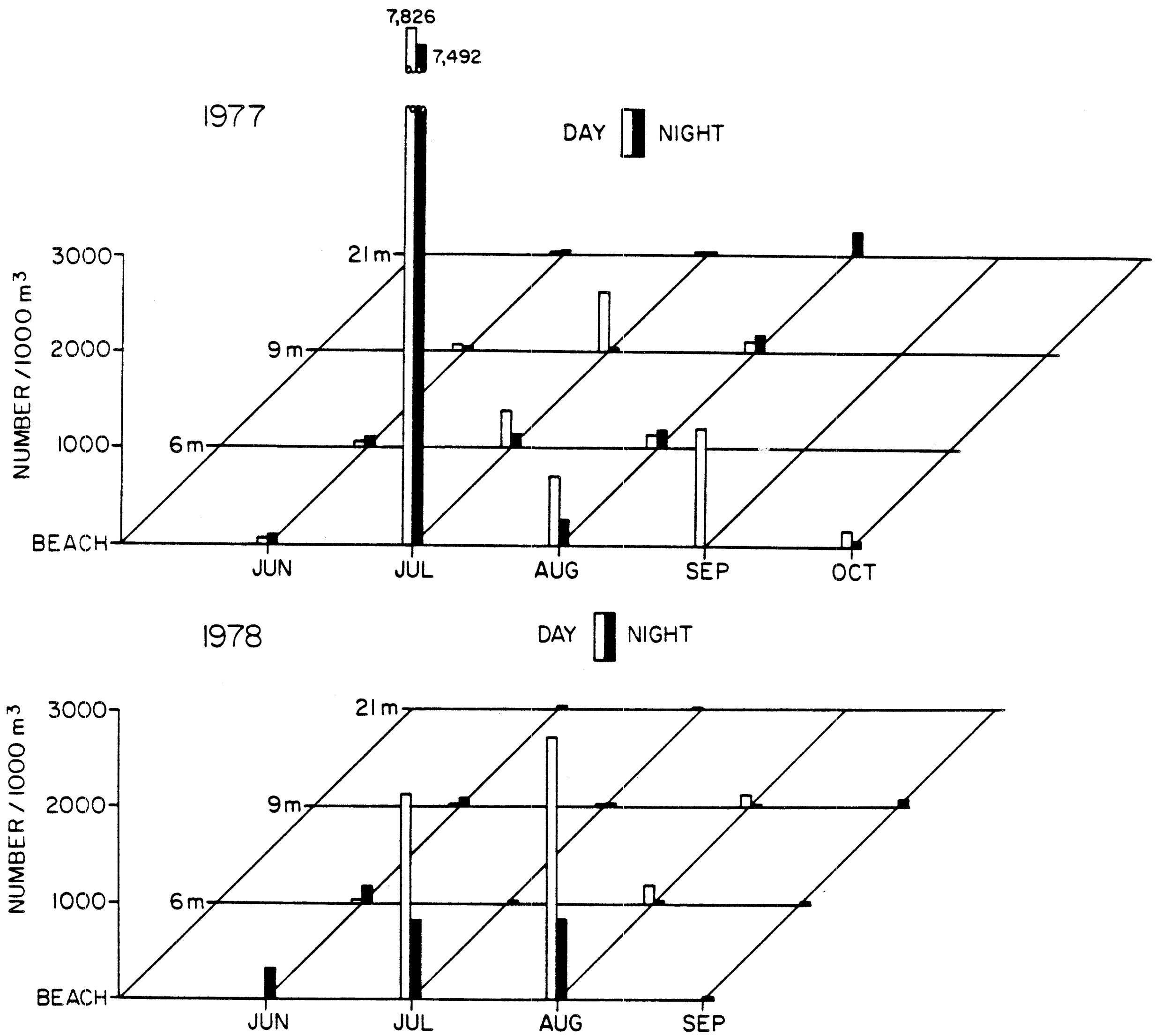
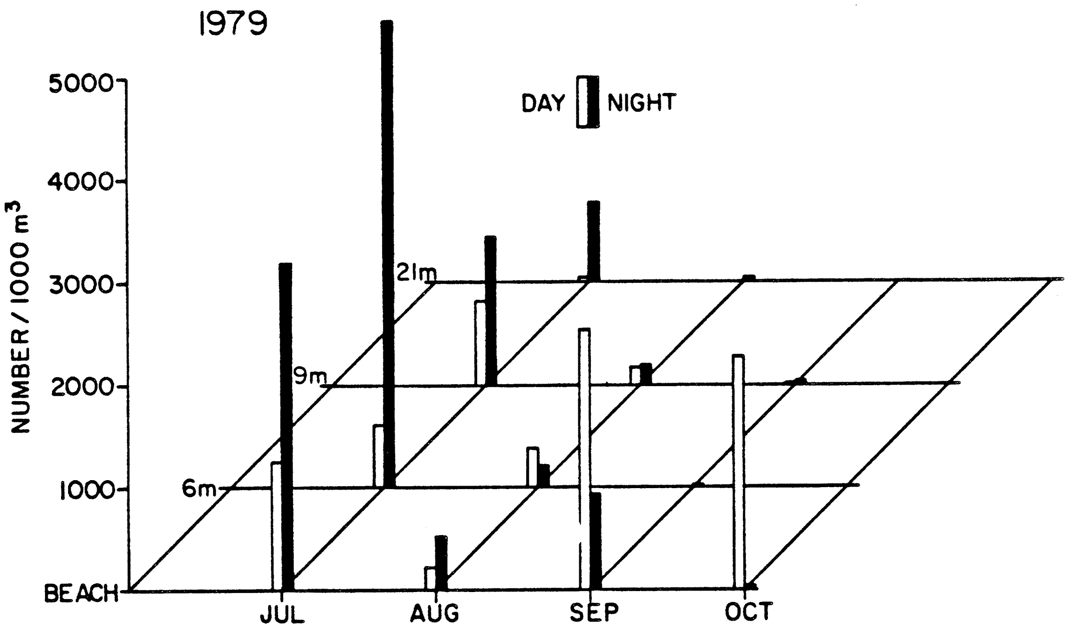


Figure 14. Mean densities (no./1,000 m³) of alewife larvae by depth contour, 1977 and 1978. Beach = stations A, B, and F; 6-m contour = stations C, G, and R; 9-m contour = stations D and H; 21-m contour = stations E and W.



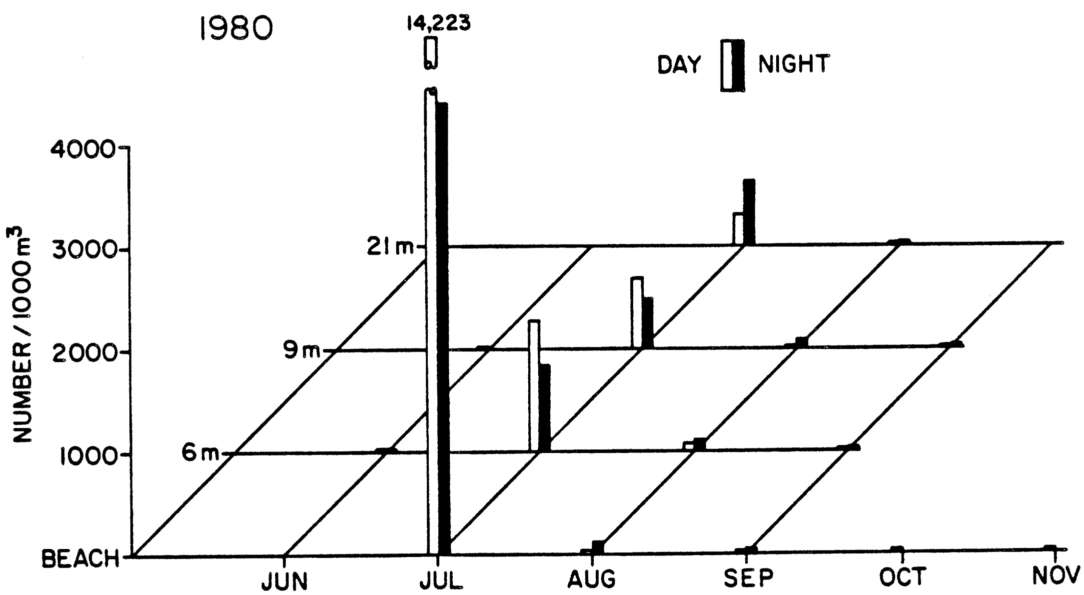
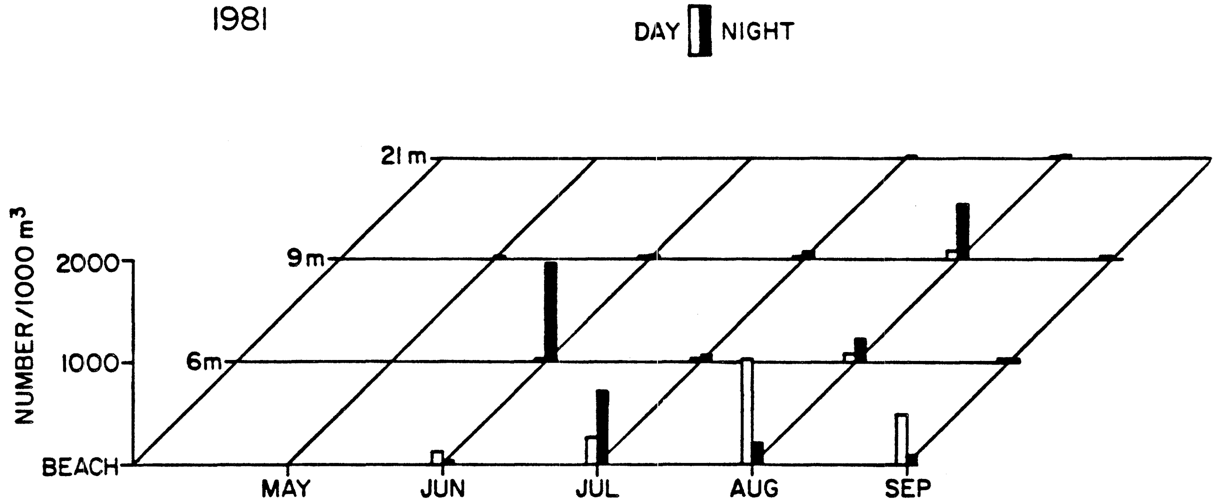


Figure 15. Mean densities (no./1,000 m^3) of alewife larvae by depth contour, 1979 and 1980. Beach = stations A, B, and F; 6-m contour = stations C, G, and R; 9-m contour = stations D and H; 21-m contour = stations E and W.



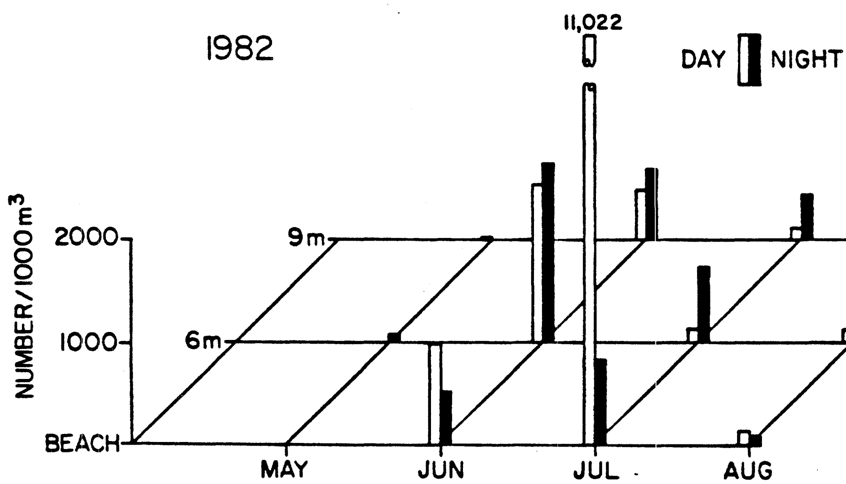


Figure 16. Mean densities (no./1,000 m³) of alewife larvae by depth contour, 1981 and 1982. Beach = stations A, B, and F; 6-m contour = stations C, G, and R; 9-m contour = stations D and H; 21-m contour = stations E and W. (21-m stations were not sampled after May, 1982.)

Table 39. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for alewife larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1973-1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1973																								
Beach-																								
Day(46)			99	236	125	174	294	330	418	442	487	209	188	243	181	82	44		6			6		
Night(48)		72	572	424	101	54	74	50	31	46	30	24	18	24	53	30	18	6	12				13	6
Open water-																								
Day(128)			14	101	110	51	35	12	7	5	<1	<1		1	2					<1				
Night(112)		6	147	223	97	53	63	31	12	5	1	1	2	2	1	3		1	6	7	4	2	3	2
1974																								
Beach-																								
Day(50)			91	261	11	3			11	2	2	8	7	17	21	25	20	8	15	6	9	15	29	11
Night(45)			39	161	56	3			9	7	2		3	2	9	35	25	8	4	3	6	3	9	8
Open water-																								
Day(125)		6	29	246	144	8	4	2	2	2	5	<1	<1	<1	<1	1	<1							
Night(124)		4	76	697	205	10	12	12	9	10	11	3	2	2	2	3	1	1	3	4	2	2	2	1
1975																								
Beach-																								
Day(48)			21	108	10	14	17	21	18	14	50	52	90	65	42	23	22	15	6	8	10	21	12	6
Night(48)		18	297	462	95	15	5	3	5	12		6	5	7	2		2	8	8	9	9	12	9	10
Open water-																								
Day(210)		<1	27	180	26	4	1	2	1	<1	<1	<1	<1	1	<1	<1	<1	<1					<1	
Night(206)	<1	8	176	113	9	1	2	2	1	2	2	3	3	4	5	5	7	7	8	5	4	2	<1	<1
1976																								
Beach-																								
Day(48)		10	421	558	61	15					3	9	12	21	3		3	24	21	8	5	2	4	2
Night(48)			181	317	116	14			2			3	10	10	5		24		9	3	6	4	10	10
Open water-																								
Day(185)		<1	11	26	22	14	12	8	3	3	3	3	4	4	3	2	1	<1	<1		<1			
Night(185)		1	33	87	45	42	17	3	3	4	7	5	5	9	10	15	20	14	6	4	3	1	1	2

Table 40. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for alewife larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1977-1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1977																								
Beach-																								
Day(48)		5	13	11	10		3			11	7	3	3	7	3	22	57	86	188	225	178	208	135	115
Night(48)			43	140	259	85	22	3	26	14	17	12	12	3	90	24	12	34	59	35		25	23	47
Open water-																								
Day(172)		<1	7	29	25	11	7	2	2	1	<1	<1	<1	<1	<1		<1	<1						
Night(146)		3	5	11	14	5	3	2	1	1	1	1	1	3	2	1	1	1	1	2	1	1	<1	<1
1978																								
Beach-																								
Day((48)		20	84	89	16	9	8	25	22	6	28	37	39	54	49	20	13	2	10	21	8	32	19	14
Night(48)		17	63	97	12		3	3		6	12			9	4	2		2		3	3	12	3	
Open water-																								
Day(179)		<1	8	8	1	<1			<1	<1	1	2	<1	<1	<1									
Night(164)		<1	12	6	<1	<1					<1	<1	<1	<1	<1	<1	<1	<1		1	<1	1	<1	<1
1979																								
Beach-																								
Day(48)			27	58	4	2		7	4	10	26	30	16	3		13	20	41	54	107	105	130	62	28
Night(48)		4	124	124	79	31	18	18		4		11	3	4						10	6	49	6	61
Open water-																								
Day(180)		2	38	60	4	2	3	3	2	2	3	2	1	1	<1	<1	<1	<1						
Night(176)			226	160	8	7	5	6	7	6	7	9	5	1	2	<1	<1	1	2	2	<1	1	1	3

Table 41. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for alewife larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1980-1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1980																								
Beach-																								
Day(48)		5	102	1445	206				3						8	8	10		4			2		
Night(48)		4	152	324	36	4	12		4	3			3	3		5	2	3	3	2	2	4	3	
Open water-																								
Day(180)		<1	12	52	46	16	9	5	1	1	1	<1	<1	<1	<1	<1	<1			<1	<1			
Night(180)		<1	6	25	22	16	11	9	7	4	2	<1	2	2	2	2	2	2	1	1	<1	<1	<1	<1
1981																								
Beach-																								
Day(48)		11	12	14	4				6	2	7	2	5		9	9	8	15	3	14	12	20	34	51
Night(48)		17	56	18	2	2	4	2	2	5	3	2	2			2		2		10	4			2
Open water-																								
Day(180)		<1	2	6	2	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	1	<1	<1
Night(180)		<1	58	24	5	4	4	2	2	1	2	2	2	1	3	3	5	2	1	1	<1	<1	<1	<1
1982																								
Beach-																								
Day(48)			34	90	5							21	28	51	100	105	111	153	231	220	169	102	62	34
Night(48)		12	42	51	9	9	2				2			2		5	2	4	7	7	10	5	2	5
Open water-																								
Day(126)		9	120	64	4	4	2	2	2	2	1	1	2	3	3	2	2	1	<1	<1	<1			<1
Night(126)		8	160	78	8	4	3	2	2	3	3	4	7	12	17	21	19	16	14	14	7	5	3	2

The most important source of the increased abundance of larval alewives at night was probably that they avoided nets more effectively in daylight. Avoidance capabilities increase as larvae grow and develop their swimming ability and vision (Houde 1969, Theilacker and Dorsey 1980). Our data provide evidence for daytime net avoidance as samples collected at night usually contained more large larvae than those collected during the day (Tables 39-41). Bimber et al. (1984) showed that during 1973-1979 the proportion of alewife larvae captured at night in the open water zone increased with body size, indicating that nighttime catches estimated abundance more reliably than daytime catches, at least for larger larvae. The same pattern was evident in our 1980-1982 data from the open water zone (Table 42).

Table 42. Night-to-day catch ratios (% caught at night) for different size groups of alewives in field samples during 1980-1982. Percentages are based on total densities (no. per 1,000 m^3) which were summed across all samples and all years at 6-, 9-, and 21-m open water stations C, D, G, H, E, R, and W and beach stations A, B, and F. N = 1,308.

Length interval (mm)	Habitat: Open Water	Habitat: Beach
0-8.0	55	28
8.1-16.0	78	13
16.1-25.0	92	6

The opposite was true in the beach zone however, as the proportion of larvae caught at night decreased sharply with increasing size (Table 42). The same trend was evident in data from the beach zone in 1973-1979 and it was suggested that the greater abundance of larger larvae in beach samples during the day may be the result of a daily migration between the beach and open water zones by larvae >8 mm TL resulting in few larvae present in the beach zone at night (Bimber et al. 1984, Jude et al. 1979b).

<u>Length-frequencies</u>-- Seasonal changes in the length-frequency distribution of larval alewives helped show pulses of spawning and tracked growth. Length-frequency histograms for 1980-1982 (Fig. 17-19) showed the same three seasonal changes that were evident in 1973-1979, i.e., (1) mean length increased

through the season as larvae grew, (2) the abundance peak at the lower end of the distribution became less pronounced by August, as spawning declined and newly hatched larvae became scarce and, (3) the greatest range of sizes occurred in midsummer when both newly hatched and older larvae were present.

Spottail Shiner

Entrainment--

General trends-- Approximately 67 million spottail shiner larvae were entrained at the Cook Plant during 1975-1982, making them the second-most-commonly entrained fish species (Table 13). Annual entrainment loss estimates ranged from 0.9 million (1976) to 28.2 million (1982) larvae. Although they were the second-most-abundant species in entrainment samples, spottail shiners only accounted for between 1.3% (1979) and 22.9% (1980) of total annual entrainment estimates. Overall, for the period 1975-1982, spottail shiner larvae represented 9% of the total projected entrainment loss.

The reduced vulnerability of spottail shiner larvae to entrainment compared with alewives probably results from several aspects of spottail shiner ecology as well as their relative abundance in the vicinity of the Cook Plant. Spottail shiner spawning is concentrated in nearshore waters (Tesar et al. 1985, Wells and House 1974) so peak hatching presumably occurs away from the realm of influence of the intakes (7-m depth contour). In addition, abundance of spottail shiner larvae in bottom sled tow samples taken at the Cook Plant in 1974 (Jude et al. 1979b) and at the J. H. Campbell Plant near Grand Haven, Mi. during 1977-1980 (Jude et al. 1981) suggests that they are largely demersal, further reducing their susceptibility to entrainment compared with the pelagic alewife larvae. Finally, spottail shiner adults were less abundant in the study areas than were alewife adults (Tesar et al. 1985) and as a result of that fact alone, we would expect fewer spottail shiner than alewife larvae entrained.

Spottail shiner larvae first appeared in entrainment samples in May (1981) or early to mid-June (all other years) and were present until late July (1977,1980), August (1975, 1978, 1979, 1981), September (1982), or even October (1976). Peak abundance of entrained spottail shiners generally occurred in June (1977, 1981, 1982) or July (1975, 1976, 1978, 1980), but sometimes occurred as late as August (1979). Greatest 24-h mean densities (number per 1,000 m^3) during 1975-1982 were 93 (15-18 July), 8 (12-16 July), 106 (21-23 June), 10 (7-8 August), 10 (1-2 August), 732 (14-15 July), 134 (15-16 June), and 153 (29 June-1 July), respectively (Tables 18-20; Bimber et al. 1984). Greatest

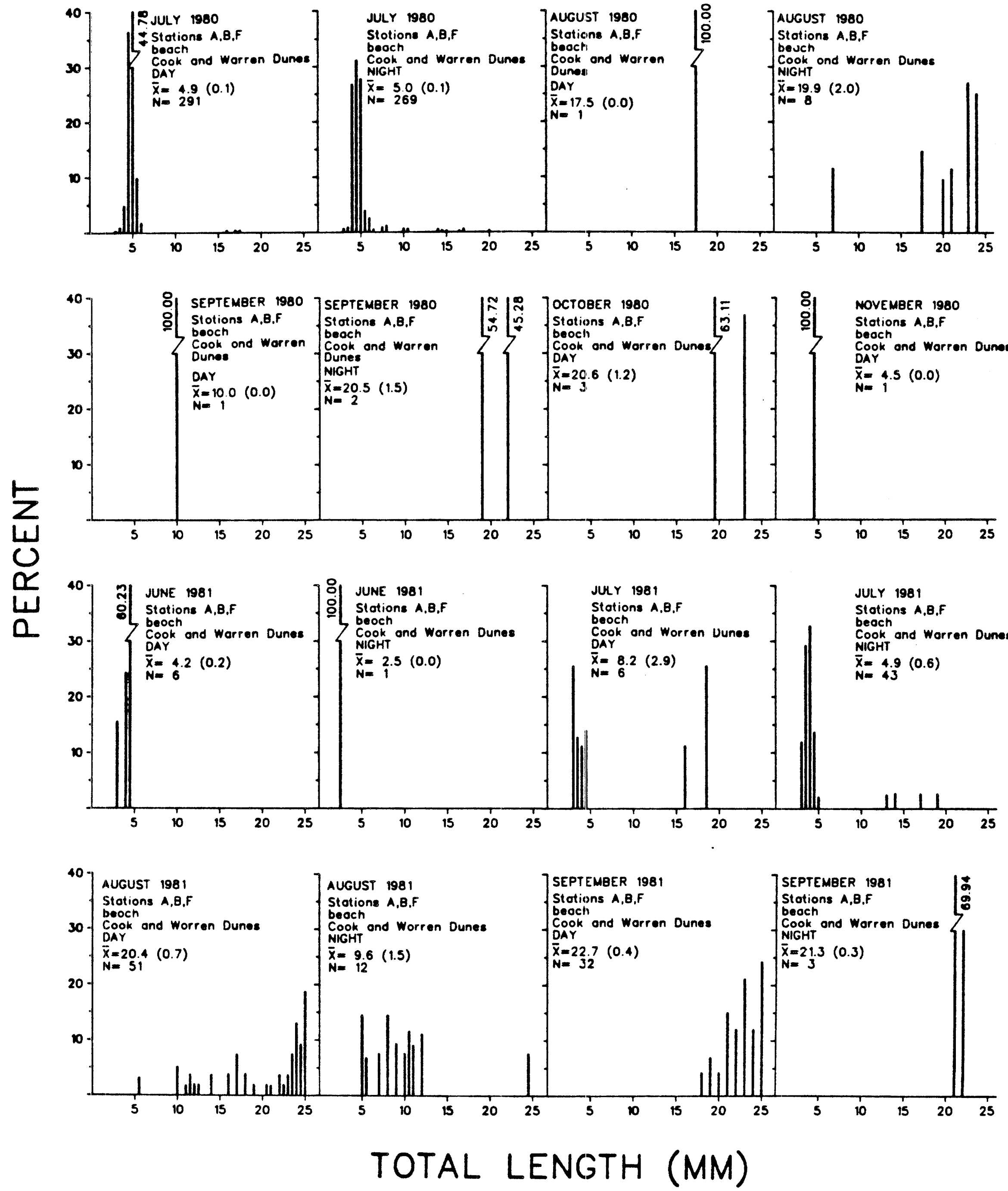


Figure 17. Length-frequency distribution of alewife larvae in the beach zone, 1980-1982.

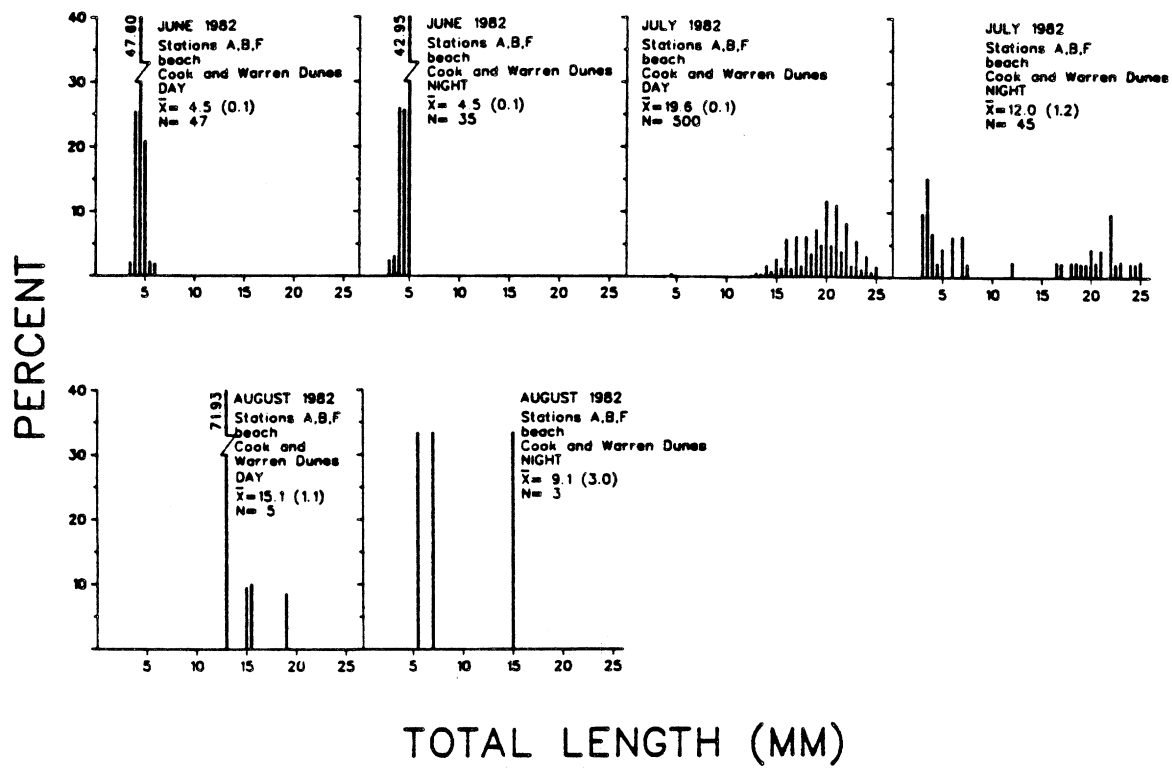


Figure 17. Continued.

individual sample densities (number per 1,000 m³) in each year were 354 (16 July 1975), 81 (4 August 1976), 511 (21 June 1977), 126 (19 July 1978), 111 (6 August 1979), 2,710 (15 July 1980), 471 (16 June 1981), and 932 (24 June 1982).

Spottail shiner larvae were more commonly entrained at night than during the day in every year of our study. Annual percentages of larval spottail shiners entrained during darkness were 90, 78, 90, 84, 82, 97, 76, and 96 for the years 1975-1982 respectively (Tables 25-27; Bimber et al. 1984).

Length-frequency distributions for spottail shiners entrained during 1980-1982 were very similar to 1975-1979 distributions. In 1980-1982 the smallest spottails collected in entrainment samples fell into the 3-mm interval (2.1-3.0 mm TL)

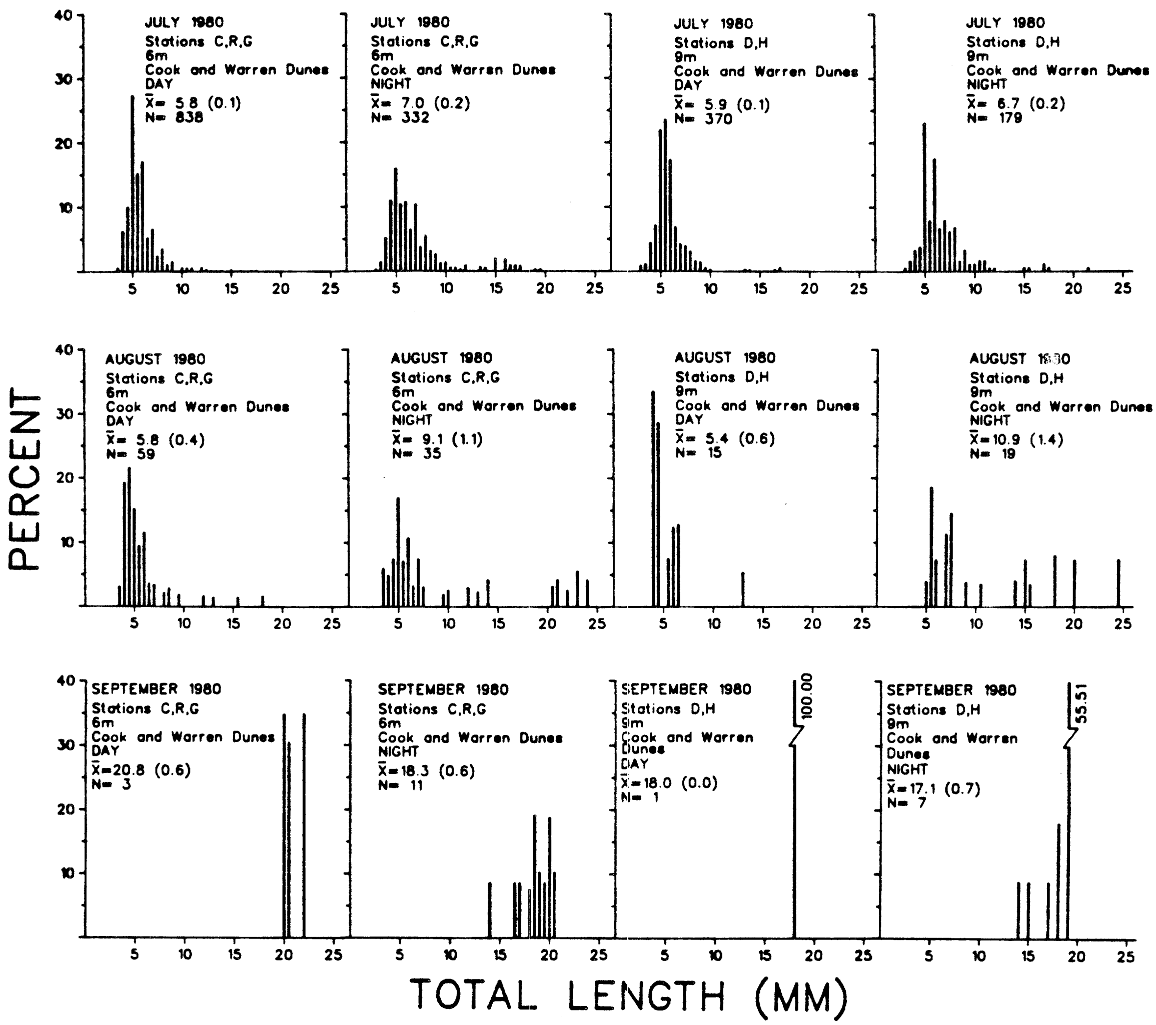


Figure 18. Length-frequency distribution of alewife larvae at 6- and 9-m stations, 1980-1982.

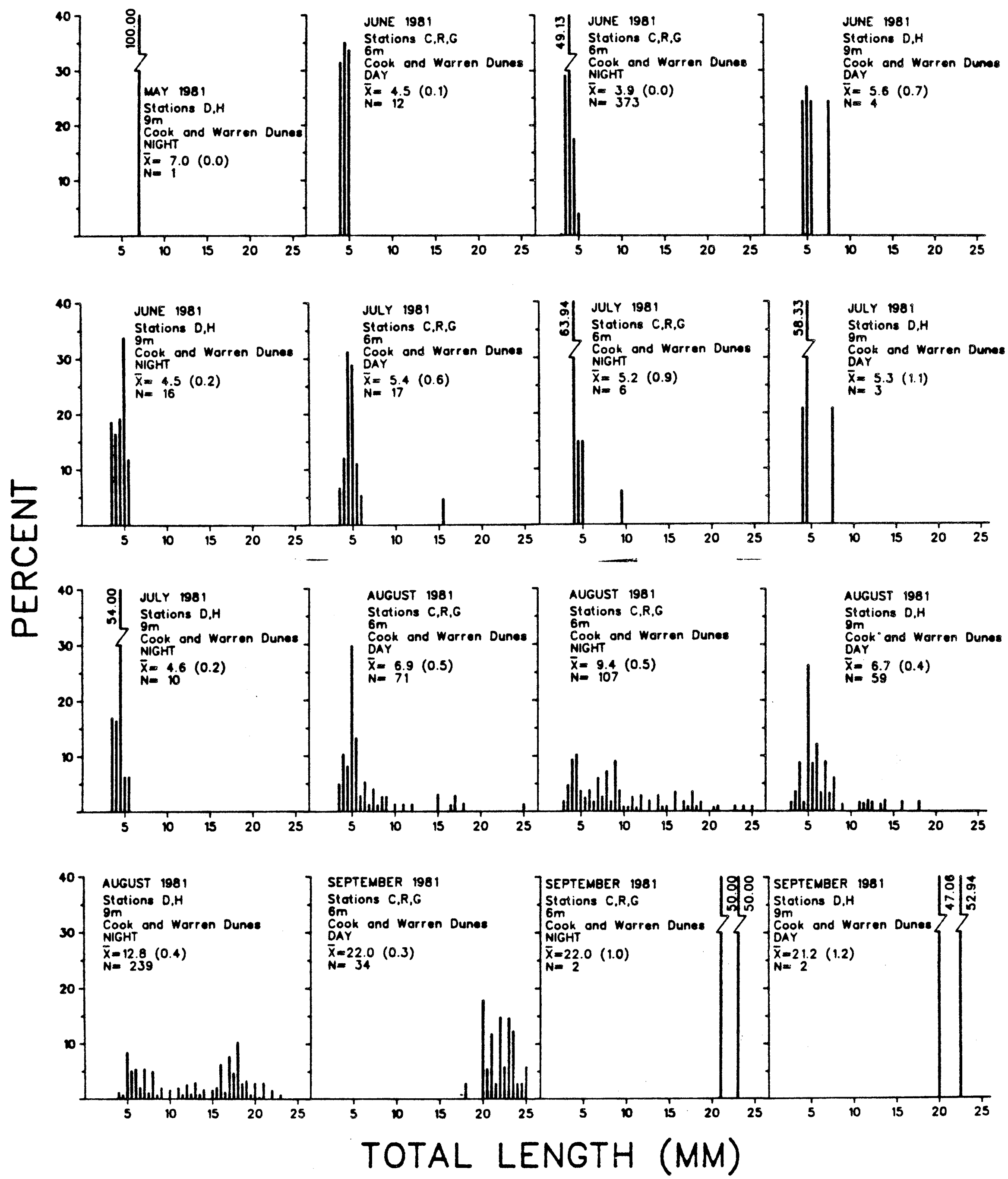


Figure 18. Continued.

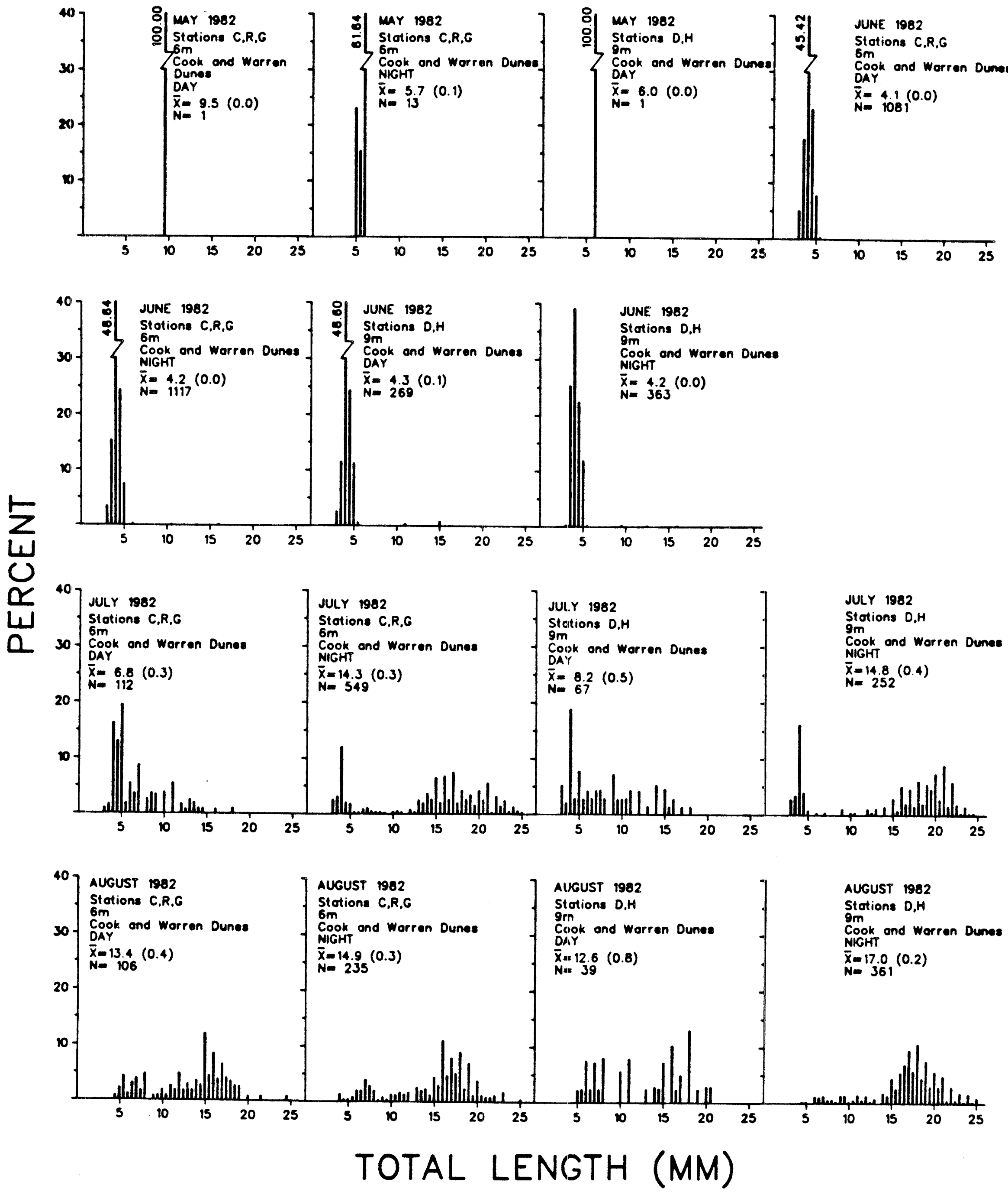


Figure 18. Continued.

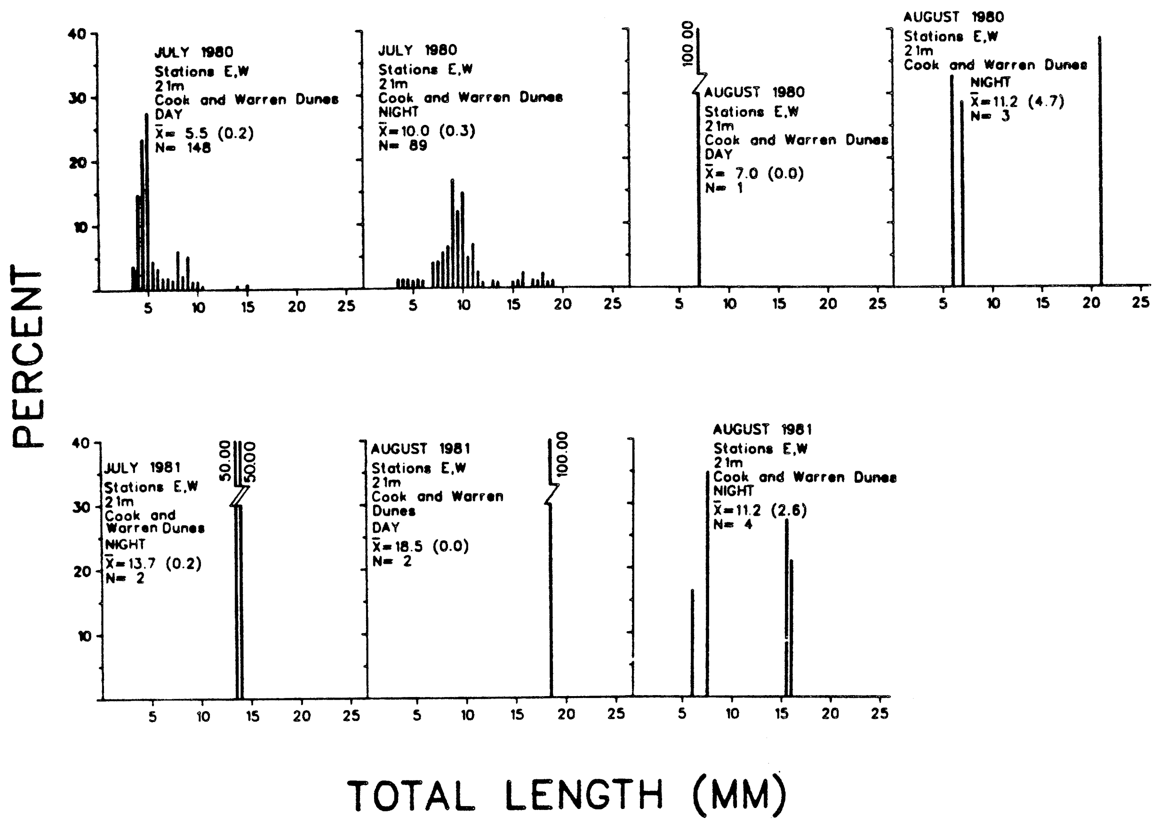


Figure 19. Length-frequency distribution of alewife larvae at 21-m stations, 1980-1981. (21-m stations were not sampled in 1982.)

and the largest within the 14-mm interval (13.1-14.0 mm) (Tables 25-27), but larger larvae were relatively rare. The majority (74%) of entrained spottail shiners were <5 mm TL, and therefore newly hatched. Spottail shiners entrained during 1975-1979 ranged in length from 2.1-3.0 mm to 11.1-12.0 mm with 73% measuring <5 mm (Bimber et al. 1984).

Field Collections--

General trends-- Occurrence of larval spottail shiners in our study areas was sharply seasonal like that of alewife, and corresponded with the period of maximum water temperatures (Figs. 6-8). Spottail shiner larvae first appeared at beach

stations in June during all years except 1977, when they were not present until the July sampling period. June was the month of first appearance in the open water zone as well, except for 1977 (July) and 1981 (May). Peak abundances of spottail shiner larvae in the beach zone occurred in June (1973, 1975, 1976, 1978), July (1974, 1977, 1979, 1980, 1982), or August (1981). During 7 of the 10 years of our study spottail shiner abundance peaked in the open water zone during the same month as in the beach zone. In 1975, abundance at open water stations peaked during July, and in 1981 and 1982 during June. Spottail shiner larvae were present in beach zone samples until August of every year except 1974, when they were still found during September.

Densities of spottail shiner larvae in the beach zone differed significantly among years (ANOVA, $p < 0.0001$). Geometric mean densities (number per 1,000 m^3) for June-August night samples only, averaged over 1973-1982, were 41, 1,142, 518, 177, 41, 36, 487, 126, 309, and 86, respectively. It is possible that our once-per-month sampling program sometimes caught and sometimes missed the period of peak abundance. Densities of spottail larvae in nighttime beach zone samples did not differ significantly between Cook Plant and Warren Dunes stations during 1973-1982 (ANOVA, $p = 0.8415$), implying no detectable plant impact.

Spottail shiner larvae were considerably less abundant in open water than in the beach zone (Tables 43-52). At open water stations, relative abundance was estimated by the number of samples in which spottail shiner larvae occurred. Larvae were found in 12 (of 280) samples in 1974, 21 (of 380) samples in 1975, 9 (of 360) in 1979, 16 (of 360) in both 1980 and 1981, 14 (of 300) in 1982, and in 4 or fewer in other years (annual sample size = about 360). Most samples from open water stations contained no spottail shiner larvae, thus precluding comparisons of densities at beach and open water stations.

A decrease in abundance of spottail larvae with increasing depth was evident by comparing the number of samples containing spottail shiner larvae at different depth contours. During the period 1973-1982 (1975-1981 for 21-m depth), 6-m stations C and G (N = 16/mo) produced 55 such samples, 9-m stations D and H (N = 20/mo) produced 20, and 21-m stations E and W (N = 16/mo) produced 3.

More spottail shiner larvae were caught at night than during the day in all years at beach stations, and in all years except 1977 and 1978 at open water stations (Tables 53-55, Appendices 4-6; Bimber et al. 1984). Most daytime samples contained no spottail shiner larvae at all. During 1973-1982, 81% of the beach zone samples and 83% of the open water samples that contained spottail shiner larvae were collected at night. This

Table 43. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1973. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
13,18 Apr (12)																								
17-18 May (12)																								
19-20 Jun (12)				119	620	119	95																	
19-20 Jul (12)				24	71		24		24			24												
8-9 Aug (12)						23																		
6-7 Sep (12)																								
10 Oct (12)																								
14-15 Nov (10)																								
OPEN WATER																								
26,28-29 Apr (32)																								
15 May (32)																								
18-19 Jun (36)				8	8																			
16-17 Jul (36)																								
21-22 Aug (36)																								
17-18 Sep (32)																								
26-27 Oct (36)																								

Table 44. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1974. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
18-20 Apr (12)																								
15-17 May (12)																								
11-12 Jun (12)			12	225	178																			
16-17 Jul (12)			37	474	462	176	194	43	32			10												
19 Aug (12)			9	28	87	153	111	201	278	70												14		9
9 Sep (12)											11	11	11	11										
8-9 Oct (11)																								
26 Nov (12)																								
OPEN WATER																								
16-17 Apr (36)																								
13-14 May (36)																								
11-12 Jun (36)				15	7																			
7-9 Jul (36)				66	50																			
19-20 Aug (33)					1																			
9-10 Sep (36)																								
7-8 Oct (36)																								

Table 45. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1975. Lengt' intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
13-14 May (12)																								
23-24 Jun (12)			71	423	211	51	12	8																
16 Jul (12)			8	610	159																			
11-13 Aug (12)										27	31	12		30				8						
9-10 Sep (12)																								
13-14 Oct (12)																								
4 Nov (12)																								
OPEN WATER																								
14,16 Apr (60)																								
13-15 May (60)																								
10-11 Jun (60)				9	5																			
15-16 Jul (60)			7	19	2																			
12-13 Aug (60)																								
10-11 Sep (60)																								
14,16-17 Oct (56)																								

Table 46. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
12-13 Apr (12)																								
10 May (12)																								
14 Jun (12)				919	957	237																		
13 Jul (12)				71	115	9	18	18							12						9	9		
9-10 Aug (12)			20	19																				
13-14 Sep (12)																								
11-12 Oct (12)																								
8 Nov (12)																								
OPEN WATER																								
13-14 Apr (60)																								
12-14 May (60)																								
21-22 Jun (51)				1																				
13-15,17 Jul (60)																								
10-11 Aug (60)																								
14-15 Sep (44)																								
19 Oct (35)																								

Table 47. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1977. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11 Apr (12)																								
17 May (12)																								
13 Jun (12)																								
12 Jul (12)			113	3,356	2,020	239	192	423	141	156	47	98	47	47				47	47					
9-10 Aug (12)			10					12											13		23		13	27
12 Sep (12)																								
10 Oct (12)																								
8 Nov (12)																								
OPEN WATER																								
17 Apr (44)																								
17-19 May (42)																								
15-16 Jun (60)																								
12,27-28 Jul (60)				1																				
9-11 Aug (60)																								
13,15 Sep (52)																								

Table 48. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1978. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
10,12 Apr (12)																								
8 May (12)																								
13-14 Jun (12)				28	27	29	19																	
10-11 Jul (12)				167	56	55																		
8-9 Aug (12)				138	14	14																		
11 Sep (12)																								
9 Oct (12)																								
15-16 Nov (12)																								
OPEN WATER																								
11,27-28 Apr (59)																								
10 May (60)																								
14,22-23 Jun (60)				1	<1																			
11-12 Jul (60)																								
9,29-30 Aug (60)			<1	1																				
12,28 Sep (44)																								

Table 49. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11-12 Apr (12)																								
7 May (12)																								
11-12 Jun (12)			84	713	47																			
11 Jul (12)			240	1,709	1,980	359	16																	
7-8 Aug (12)				100			10																	
12 Sep (12)																								
8,10 Oct (12)																								
14 Nov (12)																								
OPEN WATER																								
10-11,19 Apr (60)																								
8-10 May (60)																								
12-13 Jun (60)				1	8																			
10-11 Jul (60)				8																				
8,16-17 Aug (60)																								
11-12 Sep (56)																								

Table 50. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1980. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
7 Apr (12)																								
14 May (12)																								
9 Jun (12)				8		8	20																	
7-8 Jul (12)			12	244	754	50	18	6	6	22	6			6										
12 Aug (12)			10				8								10	20	32	17	13		21	8	38	10
8 Sep (12)																								
13 Oct (12)																								
12-13 Nov (12)																								
OPEN WATER																								
8,16-17 Apr (60)																								
13-15 May (60)																								
10-11 Jun (60)				3	1																			
8-9 Jul (60)			<1	8	1																			
12-13 Aug (60)																								
8-10 Sep (60)																								

Table 51. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1981. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
6 Apr (12)																								
14 May (12)																								
8-9 Jun (12)		77	26	137	282	50																		
8-9 Jul (12)				72	58	54	54	10	15	16		10	18											
10 Aug (12)			8	26	81	15	97	29	10	36	19													
15 Sep (12)																								
12 Oct (12)																								
9 Nov (12)																								
OPEN WATER																								
8,15-16 Apr (60)																								
12-13 May (60)				<1	2																			
9-11 Jun (60)			<1	5	7	<1																		
6-7 Jul (60)																								
12-13 Aug (60)		<1		3																				
18,22-23 Sep (60)																								

Table 52. Length-frequency distribution of spottail shiner larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
12-13 May (12)																								
16-17 Jun (12)			14	91	186	64																		
19 Jul (12)			28	290	337	12	17	17	26		8	8				20		10						
10 Aug (12)																								
13 Sep (12)																								
11-12 Oct (12)																								
9-10 Nov (12)																								
OPEN WATER																								
13-14 Apr (60)																								
10-11 May (60)																								
16-17 Jun (44)				6	2	1																		
20-21 Jul (44)				3																				
10 Aug (44)					<1	<1																		

diel difference in abundance is attributed to net avoidance. No larvae larger than 8.0 mm TL were captured during day sampling in 1980-1982, while large larvae were relatively common at night (Tables 53-55), adding weight to the theory of daytime net avoidance. A similar pattern was observed during 1973-1979 (Bimber et al. 1984).

Spottail shiner larvae were abundant enough in the beach zone during 1980-1982 to show seasonal changes in size distribution, outlining the schedule of hatching and growth (Fig. 20). As in 1973-1979, newly hatched larvae (4-5 mm TL, Auer 1982) first appeared in June and were present until July or August (Figs. 6-8). Spottail shiner larvae were absent from beach zone samples from September and October probably because the hatching period had ended by that time, and most larvae had grown to a large enough size to effectively avoid our nets.

Rainbow Smelt

Entrainment--

Rainbow smelt larvae were the third-most-abundant larvae entrained, accounting for 4.8% of the total entrainment estimates of 35.2 million larvae during 1975-1982 (Table 13). Yearly entrainment estimates of rainbow smelt larvae ranged from 0.18 million larvae in 1977 to 18.5 million in 1982. High entrainment during 1980-1982 (33.1 million larvae over the 3 years) was due in part to the high abundance of rainbow smelt larvae in the inshore area during this period (Appendices 4-6). Relatively large quantities of water used for cooling during 1980-1982 (Table 14) also contributed to the high entrainment losses. Substantial increases in water pumped through the intake occurred in May and June when rainbow smelt larvae were most abundant in the inshore area. In 1975, despite the relatively abundant populations of rainbow smelt larvae, only a moderate entrainment loss of this species (1.3 million larvae) occurred due to relatively low amounts of water used for cooling. Low entrainment of rainbow smelt larvae during 1976-1979 resulted from scarcity of larvae in the inshore water.

As was found with field distribution, entrainment of rainbow smelt larvae occurred from April to August. Monthly entrainment estimates of rainbow smelt larvae ranged from 0 to 10.8 million. Peak entrainment was observed in April during 1976, May during 1975 and 1980-1982, June during 1978, and July during 1977 and 1979 (Tables 15-17; Bimber et al. 1984). Most larvae were entrained during May. In years when rainbow smelt larvae were abundant, as in 1975 and 1980-1982, however, substantial numbers were also entrained during June. Entrainment was generally low during July and August. Peak entrainment densities during a 24-h

Table 53. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for spottail shiner larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1973-1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1973																								
Beach-																								
Day(46)					19																			
Night(48)				36	155	36	30		6			6												
Open water-																								
Day(128)																								
Night(112)				3	2																			
1974																								
Beach-																								
Day(50)			5	9	5																			
Night(45)			10	184	188	88	81	65	83	19	3	6	3	3								4		2
Open water-																								
Day(125)					<1																			
Night(124)				23	16																			
1975																								
Beach-																								
Day(48)				3																				
Night(48)			20	255	93	13	3	2		7	8	3		8				2						
Open water-																								
Day(210)						5																		
Night(206)			2	8	2																			
1976																								
Beach-																								
Day(48)					9																			
Night(48)			5	252	259	62	5	5							3						2	2		
Open water-																								
Day(185)				<1																				
Night(185)				<1																				

Table 54. Length-frequency distributions (mean densities in no./1,000 m^3) by diel period for spottail shiner larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1977-1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm) 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1977																								
Beach-																								
Day(48)				4	39														4	4			4	7
Night(48)			31	835	465	60	48	109	35	39	12	25	12	12				12	12	2				
Open water-																								
Day(172)				<1																				
Night(146)																								
1978																								
Beach-																								
Day(48)					4																			
Night(48)				83	20	25	5																	
Open water-																								
Day(179)			<1	<1	<1																			
Night(164)				<1																				
1979																								
Beach-																								
Day(48)			6	23																				
Night(48)			75	608	507	90	7																	
Open water-																								
Day(180)																								
Night(176)				3	3																			

Table 55. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for spottail shiner larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1980-1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1980																								
Beach-																								
Day(48)				8	62		2																	
Night(48)			5	56	127	15	9	2	2	5	2			2	2	5	8	4	3		5	2	9	2
Open water-																								
Day(180)			<1	<1	<1																			
Night(180)				3	<1																			
1981																								
Beach-																								
Day(48)			6	5		2																		
Night(48)		19	2	54	105	28	38	10	6	13	5	2	5											
Open water-																								
Day(180)		<1		<1																				
Night(180)			<1	2	3	<1																		
1982																								
Beach-																								
Day(48)				26	19	3																		
Night(48)			10	69	112	16	4	4	6		2	2				5		2						
Open water-																								
Day(126)					<1																			
Night(126)				3	1	<1																		

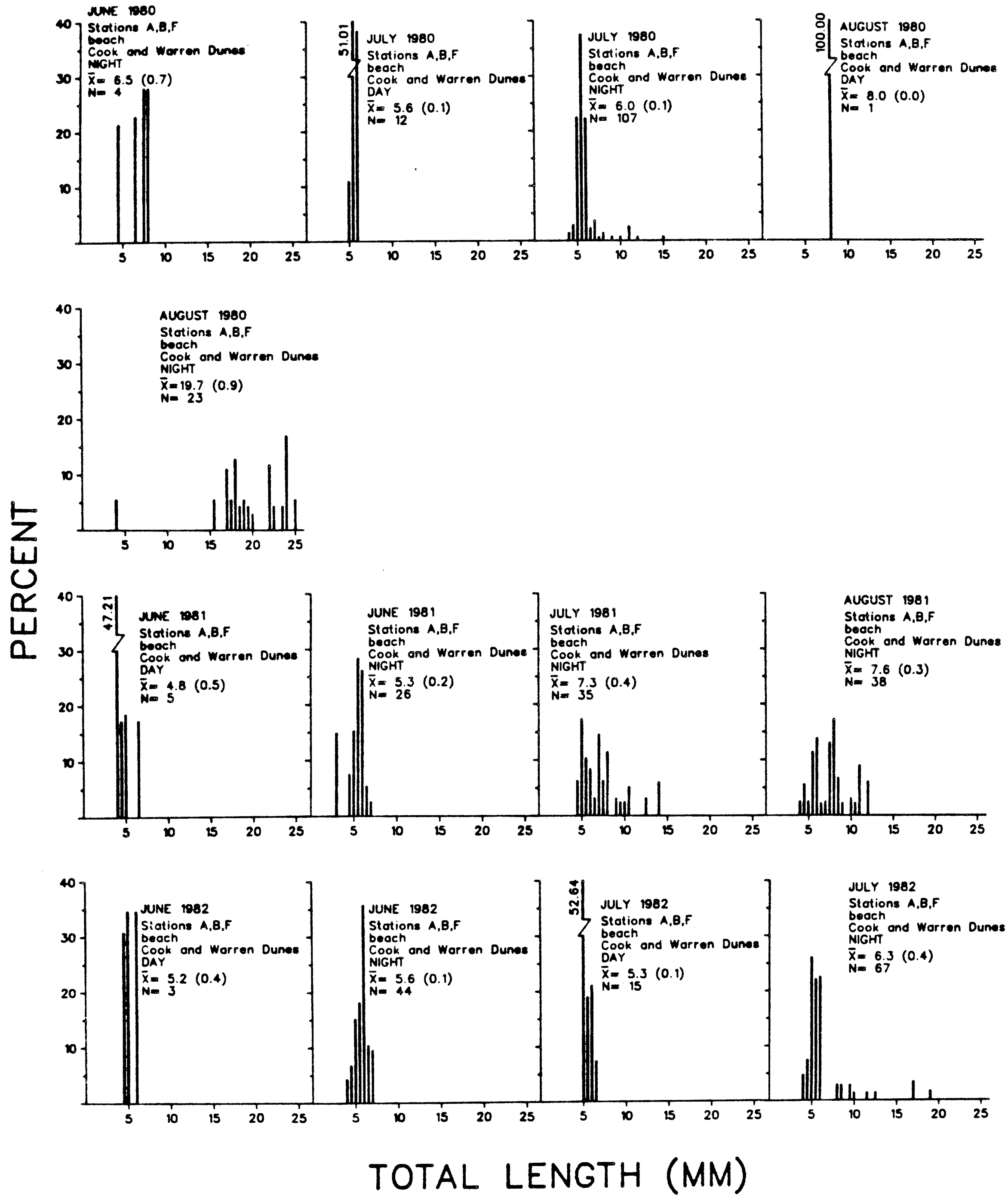


Figure 20. Seasonal growth of spottail shiner larvae in the beach zone, 1980-1982.

period for each year varied greatly, ranging from 3 larvae/1,000 m^3 during 6-7 July 1977 to 158 larvae/1,000 m^3 during 10-11 May 1982.

Like many other species of fish, rainbow smelt are most susceptible to entrainment soon after hatching. During 1975-1982, with the exception of 1977 and 1982, larvae ≤8 mm represented more than 50% of the total number of rainbow smelt larvae entrained (Tables 25-27; Bimber et al. 1984). These smaller larvae were entrained over a short period of time, mostly during May. Entrainment of larvae ≤8 mm lasted 1 to 2 wk during 1976, 1977, 1979, 1980, and 1982 and 3 to 4 wk in 1975, 1978, and 1981. Rainbow smelt larvae ≥8 mm were entrained mostly during June and July. Larger larvae (>17 mm) were entrained in substantial numbers, accounting for 14 to 78% of total rainbow smelt larvae entrainment during 1975-1982; whereas, larvae 9-17 mm made up only from 0 to 25% of the total number of rainbow smelt entrained. Relatively higher susceptibility of larvae >17 mm to entrainment may be due to their concentration near intake structure depths. Rainbow smelt larvae were entrained more commonly at night than during the day.

Field Collections--

Rainbow smelt larvae occurred in field samples over a short period in spring and summer. During 1973-1982, rainbow smelt larvae were generally first collected during May, except in 1973 when they first appeared during April (Appendices 4-6; Bimber et al. 1984). Rainbow smelt larvae were also found in entrainment samples during April in 1976, 1977, and 1979. These data indicated that early hatching of rainbow smelt larvae occurred more commonly near the Cook Plant than near the Campbell Plant (Jude et al. 1982, Tin and Jude 1983). Abundance of rainbow smelt larvae generally peaked in May and began to decline in June. Monthly densities ranged from 0 to 424 larvae/1,000 m^3 in May and from 0 to 149 larvae/1,000 m^3 in June during 1973-1982. No rainbow smelt larvae were collected in June 1974 and 1975. Rainbow smelt larvae were scarce in summer. They were collected in July, only during 1978-1980 and 1982, and in August, only during 1979-1982 (Tables 56-65).

Rainbow smelt larvae were generally more abundant in the beach zone than in open water during May, except in May 1976, 1977, and 1981 when catches were higher in the open water than at beach stations. During May 1973-1975 and 1978-1982, densities ranged from 16 to 957 larvae/1,000 m^3 in the beach and from 1.5 to 150 larvae/1,000 m^3 in the open water. During June-August, more larvae were collected in the open water than in the beach zone (Tables 56-65, Appendices 4-6). These data suggested that rainbow smelt first hatched in the beach zone and moved to deeper water soon after hatching. This suggestion was supported by

Table 56. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1973. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
13-18 Apr (12)																								
17-18 May (12)				24	24	56																		
19-20 Jun (12)																	24							
19-20 Jul (12)																								
8-9 Aug (12)																							2	
6-7 Sep (12)																								
10 Oct (12)																								
14-15 Nov (10)																								
OPEN WATER																								
26,28-29 Apr (32)				6	117	27	4																	
15 May (32)					4																			
18-19 Jun (36)																								
16-17 Jul (36)																								
21-22 Aug (36)																								
17-18 Sep (32)																								
26-27 Oct (36)																								

Table 57. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1974. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
18-20 Apr (12)																								
15-17 May (12)				12	226		26																	
11-12 Jun (12)																								
16-17 Jul (12)																								
19 Aug (12)																								
9 Sep (12)																								
8-9 Oct (11)																								
26 Nov (12)																								
OPEN WATER																								
16-17 Apr (36)																								
13-14 May (36)				5	43	91	16																	
11-12 Jun (36)																								
7-9 Jul (36)																								
19-20 Aug (33)																								
9-10 Sep (36)																								
7-8 Oct (36)																								

Table 58. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1975. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
13-14 May (12)				144	684	129																		
23-24 Jun (12)																								
16 Jul (12)																								
11-13 Aug (12)																								
9-10 Sep (12)																								
13-14 Oct (12)																								
4 Nov (12)																								
OPEN WATER																								
14,16 Apr (60)																								
13-15 May (60)				4	24	17																		
10-11 Jun (60)																								
15-16 Jul (60)													1				1					1		
12-13 Aug (60)																								
10-11 Sep (60)																								
14,16-17 Oct (56)																								

Table 59. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
12-13 Apr (12)																								
10 May (12)																								
14 Jun (12)									10															
13 Jul (12)																								
9-10 Aug (12)																								
13-14 Sep (12)																								
11-12 Oct (12)																								
8 Nov (12)																								
OPEN WATER																								
13-14 Apr (60)																								
12-14 May (60)					2	1																		
21-22 Jun (51)																								
13-15,17 Jul (60)																								
10-11 Aug (60)																								
14-15 Sep (44)																								
19 Oct (35)																								

Table 60. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1977. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11 Apr (12)																								
17 May (12)																								
13 Jun (12)																								
12 Jul (12)																								
9-10 Aug (12)																								
12 Sep (12)																								
10 Oct (12)																								
8 Nov (12)																								
OPEN WATER																								
17 Apr (44)																								
17-19 May (42)					2																			
15-16 Jun (60)							1																	
12,27-28 Jul (60)																								
9-11 Aug (60)																								
13,15 Sep (52)																								

Table 61. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1978. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
10,12 Apr (12)																								
8 May (12)					11	18	92																	
13-14 Jun (12)																								
10-11 Jul (12)									34															
8-9 Aug (12)																								
11 Sep (12)																								
9 Oct (12)																								
15-16 Nov (12)																								
OPEN WATER																								
11,27-28 Apr (59)																								
10 May (60)					1	1	1																	
14,22-23 Jun (60)									1						<1					1				
11-12 Jul (60)																								
9,29-30 Aug (60)																								
12,28 Sep (44)																								

Table 62. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11-12 Apr (12)																								
7 May (12)					16																			
11-12 Jun (12)																								
11 Jul (12)																								
7-8 Aug (12)																								
12 Sep (12)																								
8,10 Oct (12)																								
14 Nov (12)																								
OPEN WATER																								
10-11,19 Apr (60)																								
8-10 May (60)				1	11	4																		
12-13 Jun (60)						<1	3	1	<1	1		1	1											
10-11 Jul (60)							1						1				1							1
8,16-17 Aug (60)																							1	<1
11-12 Sep (56)																								

Table 63. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1980. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
7 Apr (12)																								
14 May (12)				24	204	24	8																	
9 Jun (12)																								
7-8 Jul (12)																								
12 Aug (12)																								
8 Sep (12)																								
13 Oct (12)																								
12-13 Nov (12)																								
OPEN WATER																								
8,16-17 Apr (60)																								
13-15 May (60)				10	45	22	1																	
10-11 Jun (60)						<1	1	1	1	<1		1		1	<1									
8-9 Jul (60)																<1		<1			<1	<1	<1	
12-13 Aug (60)																								
8-10 Sep (60)																								

Table 64. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1981. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
6 Apr (12)																								
14 May (12)				9																				
8-9 Jun (12)																								
8-9 Jul (12)																								
10 Aug (12)																								
15 Sep (12)																								
12 Oct (12)																								
9 Nov (12)																								
OPEN WATER																								
8,15-16 Apr (60)																								
12-13 May (60)			1	2	16	6	1																	
9-11 Jun (60)				<1			<1	1	1		1	1	1	<1	<1	1	1	1		<1				
6-7 Jul (60)																								
12-13 Aug (60)																								
18,22-23 Sep (60)																								

Table 65. Length-frequency distribution of rainbow smelt larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
12-13 May (12)				23	109	12																		
16-17 Jun (12)																				9				
19 Jul (12)																								
10 Aug (12)																								
13 Sep (12)																								
11-12 Oct (12)																								
9-10 Nov (12)																								
OPEN WATER																								
13-14 Apr (60)																								
10-11 May (60)			<1	7	24	5																		
16-17 Jun (44)					<1	<1		2	2	2	9	7	6	8	9	5	7	1		1	<1			
20-21 Jul (44)																						<1		
10 Aug (44)																	<1						<1	<1

length-frequency data (Tables 56-65). In years with enough fish to draw conclusions, 1974, 1975, and 1977-1982, larvae taken at beach stations averaged slightly smaller than those collected in open water (Tables 56-65). In 1974, when sampling was conducted weekly in May, rainbow smelt larvae appeared in the beach zone 2 weeks earlier than in open water. Absence of rainbow smelt larvae at the beach in May 1976 and 1977 probably resulted from dispersal of all larvae to offshore areas before May sampling.

Beach and open water catches varied considerably over the study period. The ANOVA of data collected in May during 1974-1975 and 1980-1982, showed significant density differences among years both in the beach zone and in open water ($p = 0.0001$). Highly variable densities in May were probably due to variations in the start of the spawning run (Rupp 1959), incubation period of rainbow smelt eggs at different temperatures (McKenzie 1964), and rapid dispersal of rainbow smelt larvae from the hatching site (Tin and Jude 1983). Data from 1976 to 1979 were not used in the statistical analysis due to low catches. Beach catches during 1974, 1975, and 1980-1982 did not differ significantly between Cook and Warren Dunes stations (ANOVA, $p = 0.48$). In the open water, densities at Cook were significantly higher than at Warren Dunes (ANOVA, $p = 0.0015$) when preoperational and operational years were combined (1974, 1975, and 1980-1982). This significance was due to the unusually high catches at 6 and 9 m during May 1974 (Bimber et al. 1984). During operational years (1975 and 1980-1982), however, no significant difference between Cook and Warren Dunes open water stations (C and D vs. G and H) was observed (Kruskal-Wallis, $p = 0.02$). These data suggested no plant impact on larval rainbow smelt populations.

Rainbow smelt larvae ranged from 3.5 to 8 mm during May and from 4.5 to 22 mm during June. Near the Campbell Plant, 105 km north of the Cook Plant, substantial hatching of rainbow smelt larvae took place in late June (Tin and Jude 1983). Scarcity of newly hatched rainbow smelt larvae (<6 mm) in June during 1973-1982 (Tables 56-65) suggested little late hatching near the Cook Plant. Most larvae collected in June were 11-15 mm.

Rainbow smelt larvae were equally abundant at 6- and 9-m stations, but less common at 21-m stations. During 1973-1974 and 1977-1982, rainbow smelt larvae densities were 67 larvae/1,000 m^3 at stations C and G (6 m) and 50 larvae/1,000 m^3 at stations D and H (9 m). The ANOVA, however, showed no significant difference in densities between the two depths ($p = 0.024$). Substantially lower densities (0.7 to 8 larvae/1,000 m^3) were observed at 21 m (stations E and W) during 1980, 1981, and 1982. Rainbow smelt larvae occurred nearly uniformly through the water column at 6- and 9-m stations, except for their absence from the surface in the day time. Rainbow smelt were generally more abundant in night samples than during the day (Tables 66-68).

Table 66. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for rainbow smelt larvae caught near the D. C. Cook Plant, southeastern Lake Michigan 1973-1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1973																								
Beach-																								
Day(46)																								
Night(48)				6	6	14																		
Open water-																								
Day(128)					<1																			
Night(112)				2	34	8	1																	
1974																								
Beach-																								
Day(50)					14																			
Night(45)				3	45		7																	
Open water-																								
Day(125)				1	5	8	<1																	
Night(124)				<1	8	19	4																	
1975																								
Beach-																								
Day(48)				15	114	30																		
Night(48)				21	57	2																		
Open water-																								
Day(210)				<1	3																			
Night(206)				1	3								<1				<1					<1		
1976																								
Beach-																								
Day(48)									3															
Night(48)																								
Open water-																								
Day(185)					<1	<1																		
Night(185)					<1	<1																		

Table 67. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for rainbow smelt larvae caught near the D. C. Cook Plant, southeastern Lake Michigan 1977-1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1977																								
Beach-																								
Day(48)																								
Night(48)																								
Open water-																								
Day(172)							<1																	
Night(146)					<1																			
1978																								
Beach-																								
Day(48)																								
Night(48)					3	5	23		8															
Open water-																								
Day(179)																								
Night(164)					<1	<1	<1		<1															
1979																								
Beach-																								
Day(48)					4																			
Night(48)																								
Open water-																								
Day(180)					<1	<1		<1	<1			<1	<1											<1
Night(176)				<1	4	1	1	<1		<1		<1	1				<1						<1	<1

Table 68. Length-frequency distributions (mean densities in no./1,000 m^3) by diel period for rainbow smelt larvae caught near the D. C. Cook Plant, southeastern Lake Michigan 1980-1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1980																								
Beach-																								
Day(48)				3	41	3																		
Night(48)				4	10	3	2																	
Open water-																								
Day(180)				<1	<1	2	<1	<1								<1						<1		
Night(180)				3	14	6	1	<1	<1	<1		<1		<1	<1			<1			<1		<1	
1981																								
Beach-																								
Day(48)																								
Night(48)				2																				
Open water-																								
Day(180)			<1	<1	1	1	<1		<1		<1				<1	<1	<1			<1				
Night(180)				<1	4	1	<1	<1				<1	<1	<1		<1	<1	<1						
1982																								
Beach-																								
Day(48)					27															2				
Night(48)				6		3																		
Open water-																								
Day(126)			<1	2	3	<1					<1	<1	<1	<1	<1	<1	1				<1			
Night(126)				1	9	2		1	1	1	3	2	2	3	3	1	1	<1		<1		<1	<1	<1

Yellow Perch

Entrainment--

During 1975-1982, yellow perch larvae accounted for 1.8% (13.4 million) of total entrainment estimates. Yearly entrainment estimates fluctuated considerably, ranging from 38,000 larvae in 1976 to 5.0 million larvae in 1982 (Table 13, Fig. 5). In most cases, the number of yellow perch larvae entrained appeared to be related to larval yellow perch abundance in inshore water. Low entrainment generally occurred during years when low larval yellow perch densities were observed in field samples (1975, 1976, 1979, and 1980), whereas, high entrainment rates occurred during periods of high larval yellow perch abundance (1977 and 1982). Substantial numbers of yellow perch larvae were entrained, however, in 1978 and 1981 when low larval yellow perch populations were observed in inshore areas.

Yellow perch larvae were found in entrainment samples from April to August, with most being observed in June. Perch larvae were entrained in April, only during 1975 and 1976, and in May, only during 1977, 1978, 1980, and 1981. They occurred in June entrainment samples every year during 1975-1982. Monthly entrainment estimates ranged from 0 to 200,000 larvae during April and May, and from 29,000 to 4.9 million during June (Tables 15-17; Bimber et al. 1984). Entrainment continued at low levels in July every year, except in July 1982 when no perch larvae were entrained. No yellow perch larvae were found in August entrainment samples, except in 1982. Densities in 24-h entrainment samples were generally highest during June (Figs. 9-11), except in 1975, when the peak occurred in July. Peak densities in a 24-h period ranged from 0.1 to 74 larvae/1,000 m^3.

Although larval yellow perch collected in entrainment samples during 1975-1982 ranged in length from 3 to 11 mm, the vast majority (98%) were newly hatched (≤7 mm TL). Elevated susceptibility to entrainment for hatchlings compared with older, larger larvae, occurs for many fish species, particularly yellow perch larvae, which are planktonic when newly hatched (Houde 1969). Decline in entrainment rates as larvae attain greater size is likely the result of a combination of factors including increased avoidance capabilities, a possible shift in distribution away from the influence of intakes, and natural mortality. Since newly hatched yellow perch larvae are usually 5 to 6 mm (Auer 1982) and normally grow about 0.5 mm per day (Mansueti 1964), the largest perch larvae entrained were less than 2 wk old.

More yellow perch larvae were entrained at night than during the day in all years, except 1976 and 1981. Their ability to avoid intakes during the day and less so at night probably

contributed to this phenomenon. In 1975, 1978, 1979, and 1980, greatest mean annual density occurred during dusk-midnight sampling. Midnight-dawn samples showed greatest annual mean density of yellow perch larvae in 1977 and 1982. Greatest annual mean density in 1976 and 1981 occurred during noon-dusk sampling. In 1976, the year of lowest total projected entrainment for yellow perch, no yellow perch larvae were entrained at night. Densities of entrained yellow perch were generally lowest during dawn-noon sampling.

Field Collections--

The season of occurrence of yellow perch larvae was usually shorter and began earlier than those of alewife and spottail shiner. Yellow perch larvae were first collected during April in 1973 and 1978, May in 1979-1981, June in 1974-1977 and 1982 (Figs. 6-8; Bimber et al. 1984). Since adult yellow perch in the study area ordinarily did not attain spawning conditions until May, the early larvae probably entered Lake Michigan from inland lakes or rivers, where spawning begins sooner than in Lake Michigan (Perrone et al. 1983). Yellow perch larvae were generally scarce during April and May, with densities ranging from 0 to 22.6 larvae/1,000 m^3 (Appendices 4-6). They were found in April, only during 1973 and 1978, and in May, only during 1973 and 1978-1981. The month of peak abundance was generally June as was observed in 1973, 1975, 1977-1979 and 1982. Highest densities occurred during May in 1980 and 1981, and during July in 1976 (Appendices 4-6; Bimber et al. 1984). Peak monthly densities ranged from 0.9 larvae/1,000 m^3 in July 1976 to 205 larvae/1,000 m^3 during June 1982. Larvae were scarce during July and August (Tables 69-78), presumably due to net avoidance.

During April, yellow perch larvae were taken only in open water. During May, they were more common in the beach zone than in open water. During June, more larvae were collected in the open water, except in 1978, 1979, 1980, and 1981 when higher densities were observed at beach stations. Larval yellow perch densities in the beach varied greatly, ranging from 0 to 91 larvae/1,000 m^3 in May and from 0 to 324 larvae/1,000 m^3 in June. In the open water, yellow perch larvae occurred in May samples only during 1981, but were collected in June every year during 1973-1982. All yellow perch larvae caught in July and August were found in open water.

Densities of yellow perch larvae in open water during June were significantly different among years (ANOVA, $p < 0.0001$). This significance was due to highly variable open water densities (7 to 167 larvae/1,000 m^3). The ANOVA was based on data collected during 1973, 1974, and 1977-1982. Catches of yellow perch larvae during 1975 and 1976 were too low for statistical

Table 69. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1973. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
13,18 Apr (12)																								
17-18 May (12)							24																	
19-20 Jun (12)																								
19-20 Jul (12)																								
8-9 Aug (12)																								
6-7 Sep (12)																								
10 Oct (12)																								
14-15 Nov (10)																								
OPEN WATER																								
26,28-29 Apr (32)						2																		
15 May (32)																								
18-19 Jun (36)					10	13	5																	
16-17 Jul (36)																								
21-22 Aug (36)																								
17-18 Sep (32)																								
26-27 Oct (36)																								

Table 70. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1974. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
18-20 Apr (12)																								
15-17 May (12)																								
11-12 Jun (12)					53	66																		
16-17 Jul (12)																								
19 Aug (12)																								
9 Sep (12)																								
8-9 Oct (11)																								
26 Nov (12)																								
OPEN WATER																								
16-17 Apr (36)																								
13-14 May (36)																								
11-12 Jun (36)				2	50	54																		
7-9 Jul (36)					11																			
19-20 Aug (33)																								
9-10 Sep (36)																								
7-8 Oct (36)																								

Table 71. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1975. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
13-14 May (12)																								
23-24 Jun (12)																								
16 Jul (12)																								
11-13 Aug (12)																								
9-10 Sep (12)																								
13-14 Oct (12)																								
4 Nov (12)																								
OPEN WATER																								
14,16 Apr (60)																								
13-15 May (60)																								
10-11 Jun (60)					2		<1																	
15-16 Jul (60)					1																			
12-13 Aug (60)																								
10-11 Sep (60)																								
14,16-17 Oct (56)																								

Table 72. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
12-13 Apr (12)																								
10 May (12)																								
14 Jun (12)																								
13 Jul (12)																								
9-10 Aug (12)																								
13-14 Sep (12)																								
11-12 Oct (12)																								
8 Nov (12)																								
OPEN WATER																								
13-14 Apr (60)																								
12-14 May (60)																								
21-22 Jun (51)					2	<1	<1																	
13-15,17 Jul (60)					2																			
10-11 Aug (60)																								
14-15 Sep (44)																								
19 Oct (35)																								

Table 73. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1977. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11 Apr (12)																								
17 May (12)																								
13 Jun (12)						7																		
12 Jul (12)																								
9-10 Aug (12)																								
12 Sep (12)																								
10 Oct (12)																								
8 Nov (12)																								
OPEN WATER																								
17 Apr (44)																								
17-19 May (42)																								
15-16 Jun (60)			5	10	36	20	3	<1				1												
12,27-28 Jul (60)						<1																		
9-11 Aug (60)																								
13,15 Sep (52)																								

Table 74. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1978. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
10,12 Apr (12)																								
8 May (12)						45	11																	
13-14 Jun (12)				19	55	9																		
10-11 Jul (12)																								
8-9 Aug (12)																								
11 Sep (12)																								
9 Oct (12)																								
15-16 Nov (12)																								
OPEN WATER																								
11,27-28 Apr (59)					<1																			
10 May (60)																								
14,22-23 Jun (60)			2	5	10	2																		
11-12 Jul (60)					3																			
9,29-30 Aug (60)																								
12,28 Sep (44)																								

Table 75. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
11-12 Apr (12)																								
7 May (12)						6	11																	
11-12 Jun (12)					128	9																		
11 Jul (12)																								
7-8 Aug (12)																								
12 Sep (12)																								
8,10 Oct (12)																								
14 Nov (12)																								
OPEN WATER																								
10-11,19 Apr (60)																								
8-10 May (60)																								
12-13 Jun (60)				<1	4	<1																		
10-11 Jul (60)				2	7	10	1	1	1	<1														
8,16-17 Aug (60)																								
11-12 Sep (56)																								

Table 76. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1980. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
7 Apr (12)																								
14 May (12)					36		41	14																
9 Jun (12)					10	27																		
7-8 Jul (12)																								
12 Aug (12)																								
8 Sep (12)																								
13 Oct (12)																								
12-13 Nov (12)																								
OPEN WATER																								
8,16-17 Apr (60)																								
13-15 May (60)																								
10-11 Jun (60)				4	6	3																		
8-9 Jul (60)				<1	13	2	1	2	1										<1					
12-13 Aug (60)																								
8-10 Sep (60)																								

Table 77. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m³)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1981. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

	Length interval (mm)																							
Date (N)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
6 Apr (12)																								
14 May (12)						10	10	7																
8-9 Jun (12)																								
8-9 Jul (12)																								
10 Aug (12)																								
15 Sep (12)																								
12 Oct (12)																								
9 Nov (12)																								
OPEN WATER																								
8,15-16 Apr (60)																								
12-13 May (60)							1																	
9-11 Jun (60)			<1	<1	2	4																		
6-7 Jul (60)						<1																		
12-13 Aug (60)																								
18,22-23 Sep (60)																								

Table 78. Length-frequency distribution of yellow perch larvae (mean densities (no./1,000 m^3)) caught near the D. C. Cook Plant, southeastern Lake Michigan, 1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Date (N)	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BEACH																								
15 Apr (12)																								
12-13 May (12)																								
16-17 Jun (12)					266	55																		
19 Jul (12)																								
10 Aug (12)																								
13 Sep (12)																								
11-12 Oct (12)																								
9-10 Nov (12)																								
OPEN WATER																								
13-14 Apr (60)																								
10-11 May (60)																								
16-17 Jun (44)				23	181	24																		
20-21 Jul (44)																								
10 Aug (44)							<1																	

analysis. Larval yellow perch abundance in preoperational and operational years followed no patterns attributable to plant operations. Yellow perch larvae were scarce at Warren Dunes and Cook stations in preoperational year 1973 and operational years, 1975, 1976, 1978-1981. They were abundant in both areas in 1974, 1977, and 1982. The Kruskal-Wallis test revealed no significant difference in open water densities in June between preoperational years (1973, 1974) and operational years (1977-1982) ($p = 0.155$). During operational years (1977-1982), open water densities at Cook were not significantly different from those at Warren Dunes stations (Kruskal-Wallis, $p = 0.768$). Thus we infer no plant impact on the distribution of yellow perch larvae.

Yellow perch larvae were equally common at 6- and 9-m stations. The ANOVA showed no significant density difference between 6-m stations (C and D) and 9-m stations (D and H) during June 1973, 1974, and 1977-1982. Mean densities at 6- and 9-m stations over the period 1973, 1974, and 1977-1982 were respectively 63 and 50 larvae/1,000 m^3. At 6- and 9-m stations, abundance was similar at all depth strata, except for the deepest stratum, where yellow perch larvae were less frequently taken. Abundance of yellow perch larvae also declined at greater depth contours. At stations E and W (21 m) mean density was only 5 larvae/1,000 m^3 during June 1975-1981.

In the beach zone, more yellow perch larvae were caught at night than during the day, due probably to net avoidance during daylight. In the open water, larval fish densities were also generally higher at night than during the day (Tables 79-81). However, no significant difference between day and night densities in the open water during 1973, 1974 and 1977-1982 were found (ANOVA, $p = 0.395$).

Yellow perch larvae collected ranged from 3.5 to 10.5 mm, most being 7.5 mm and smaller (Tables 69-81). Increased net avoidance by larger larvae probably contributed to the complete absence of larvae larger than 10.5 mm from field samples as well as scarcity of larvae from July samples. Only 5% of the yellow perch larvae caught in field samples were >7.5 mm TL. Survival rate from the egg to 8 mm in Oneida Lake is about 5-14% (Clady and Hutchinson 1975), so that net avoidance was not the sole cause of rarity of larger larvae. In fact, we believe that juvenile and adult alewife, which are common at this time in inshore waters, preyed on a substantial number of newly hatched yellow perch (Jude and Tesar 1985). Yellow perch larvae are passive at this stage (Houde 1969) and would be easy prey for alewives. In fact when alewives declined in 1980, yellow perch larvae densities increased dramatically. Juvenile and adult yellow perch populations have subsequently rebounded as a result of the alewife decline (Jude and Tesar 1985).

Table 79. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for yellow perch larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1973-1976. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1973																								
Beach-																								
Day(46)																								
Night(48)							6																	
Open water-																								
Day(128)					2	1	1																	
Night(112)					1	4																		
1974																								
Beach-																								
Day(50)					4	4																		
Night(45)					10	13																		
Open water-																								
Day(125)					4	2																		
Night(124)				1	13	13																		
1975																								
Beach-																								
Day(48)																								
Night(48)																								
Open water-																								
Day(210)					<1																			
Night(206)					1		<1																	
1976																								
Beach-																								
Day(48)																								
Night(48)																								
Open water-																								
Day(185)						<1	<1																	
Night(185)					1																			

Table 80. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for yellow perch larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1977-1979. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1977																								
Beach-																								
Day(48)																								
Night(48)						2																		
Open water-																								
Day(172)			1	<1	2	3	<1																	
Night(146)			1	3	12	5	1	<1	<1															
1978																								
Beach-																								
Day(48)																								
Night(48)				5	14	14	3																	
Open water-																								
Day(179)				<1	2																			
Night(164)			1	1	3	1																		
1979																								
Beach-																								
Day(48)					18																			
Night(48)					14	4	3																	
Open water-																								
Day(180)				<1	2	1	<1	<1		<1														
Night(176)				<1	2	3	<1		<1															

Table 81. Length-frequency distributions (mean densities in no./1,000 m³) by diel period for yellow perch larvae caught near the D. C. Cook Plant, southeastern Lake Michigan, 1980-1982. Length intervals are in mm (e.g., the 5-mm interval includes all larvae from 4.1 to 5.0 mm TL). Blanks indicate zero densities. Sample sizes are in parentheses.

Year/ Sampling zone/ Diel period	Length interval (mm)																							
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1980																								
Beach-																								
Day(48)					5	2																		
Night(48)					6	4	10	4																
Open water-																								
Day(180)				<1	1	1		<1	<1										<1					
Night(180)				1	5	1	<1	<1	<1															
1981																								
Beach-																								
Day(48)						3	3	2																
Night(48)																								
Open water-																								
Day(180)			<1	<1	1	<1																		
Night(180)					<1	1	<1																	
1982																								
Beach-																								
Day(48)					36	10																		
Night(48)					30	3																		
Open water-																								
Day(126)				5	24	5																		
Night(126)				3	40	3	<1																	

Less Abundant Species

Fourteen species of larval fishes were captured in small numbers in field samples during 1973-1982. These included burbot, trout-perch, common carp, johnny darter, deepwater (formerly fourhorn) sculpin, slimy sculpin, ninespine stickleback, quillback, gizzard shad, emerald shiner, and unidentified members of the sucker, minnow, sculpin, and herring families. All these species, except gizzard shad, emerald shiner, and unidentified sucker larvae, were also collected in entrainment samples. In addition, entrainment samples also contained small numbers of mottled sculpin and unidentified darter larvae. Among the less abundant species, trout-perch and johnny darter larvae were most frequently observed both in field and entrainment samples. Common carp and burbot larvae were more common in field than in entrainment samples. In contrast, slimy sculpin larvae occurred more frequently in entrainment than in field samples.

Burbot--

Burbot larvae were collected in field samples during 1975, 1976, and 1978-1982. The highest number of samples containing burbot larvae in any year was seven (1982). Densities in a sample ranged from 16 to 512 larvae/1,000 m^3. Most burbot larvae were collected during April and May. A few burbot larvae were found in June during 1979 and 1980. These data agreed with Mansfield et al. (1983) who reported burbot larvae hatched during late April and May in Lake Michigan. Burbot larvae were found in water up to 21 m deep, but their densities tended to be higher in the beach zone than in open water. Burbot larvae we collected were mostly 3.5-5.0 mm, i.e., newly hatched (Mansfield et al. 1983). A 6-mm larva was caught in 1974 and a 14-mm larva in 1976.

Burbot larvae were entrained only in 1976, 1978, and 1982. Entrainment estimates for the 3 years were 0.46 million larvae. Burbot larvae were found in entrainment samples during March, April, and June. They ranged from 3.5 to 6 mm TL.

Trout-perch--

Trout-perch larvae were collected every year from 1974 to 1982. Although juvenile and adult trout-perch were common in the study area, larval trout-perch were generally scarce. Trout-perch larvae were found only in one to three samples every year. Densities of larvae in a sample generally ranged from 15 to 149 larvae/1,000 m^3, except for a 1977 sample which contained 1041 larvae/1,000 m^3. Trout-perch larvae occurred from May to

October, suggesting that trout-perch had the longest spawning and hatching season of any species collected in this study. Trout-perch larvae were dispersed throughout the study area, but were more commonly found in the beach zone than in open water. More trout-perch larvae were collected at Cook than at Warren Dunes. Of the 14 samples containing trout-perch larvae, only four were taken at Warren Dunes stations. Most trout-perch larvae were caught at night (Appendices 4-6). Trout-perch larvae ranged from 4 to 6 mm TL, except an 8-mm larva collected in May 1976.

Entrainment estimates for trout-perch larvae during 1975-1982 (4.5 million larvae) accounted for 0.6% of total entrainment. Trout-perch larvae were entrained every year; the highest projected losses were observed in 1975 (1 million larvae) and 1982 (1.4 million larvae). Due to the very long spawning season of trout-perch, entrainment of larval trout-perch took place over an extended period. Trout-perch larvae were normally entrained from June to October, but in 1976 they occurred in February and November entrainment samples (Appendices 1-3; Bimber et al. 1984). Most trout-perch larvae were entrained during August, September, and October (Tables 15-17; Bimber et al. 1984). The number of entrainment samples containing trout-perch larvae ranged from 1 in 1978 to 9 in 1982. Greatest densities in individual samples were: 46 larvae/1,000 m^3 (October 1975), 17 larvae/1,000 m^3 (17 July 1976), 42 larvae/1,000 m^3 (22 August 1977), 35 larvae/1,000 m^3 (1 August 1978), 75 larvae/1,000 m^3 (27 June 1979), 78 larvae/1,000 m^3 (20 June 1980), 42 larvae/1,000 m^3 (16 June 1981), and 46 larvae/1,000 m^3 (6 October 1982). Most larvae were entrained at night. Only 5 of the 45 samples containing trout-perch were collected during the day. Entrained trout-perch larvae ranged from 4.0 to 19.3 mm TL.

Johnny Darter--

Johnny darter larvae were collected during 1976, 1977, and 1979-1982. Generally only one to three field samples contained johnny darter larvae each year; in 1982 however, johnny darter larvae occurred in nine samples. Johnny darter larvae were caught mostly during June and July; a few occurred during August in 1980 and during April in 1982. Johnny darter larvae were found mostly in open water. Of the 21 samples containing johnny darter larvae, only three were taken in the beach zone. More johnny darter larvae were caught at Cook than at Warren Dunes stations (Appendices 4-6). In the study of fish populations near the J. H. Campbell Plant, Jude et al. (1982) attributed the higher abundance of johnny darter at plant stations compared with reference stations to the presence of rock riprap at the intake and discharge structures. Densities of larvae in a sample generally ranged from 13 to 150 larvae/1,000 m^3. In 1977,

however, a density of 1,041 larvae/1,000 m^3 was observed in the beach zone. Most johnny darter larvae we collected were newly hatched (4-6 mm TL).

Johnny darter larvae were entrained in every year except 1980. Entrainment estimates (3.4 million larvae) accounted for 0.4% of projected total entrainment (Table 13). Entrainment was highest in 1977, 1978, and 1982 (Table 13). Johnny darter entrainment occurred during June, July, and August; most larvae were entrained during June. The number of entrainment samples containing johnny darter larvae ranged from one in 1975 to nine in 1977. Densities of larvae in individual samples ranged from 15 to 185 larvae/1,000 m^3. Entrained johnny darter larvae ranged from 4 to 18 mm TL.

Common Carp--

Common carp larvae were collected in field samples during 1975, 1976, 1978, 1980, and 1982. They were abundant in 1975, 1976, and 1982, with peak densities in a sample of 2,505 larvae/ 1,000 m^3, 11,814 larvae/1,000 m^3, and 5,632 larvae/1,000 m^3 respectively. During 1978 and 1980, the highest density observed was 144 larvae/1,000 m^3. Common carp larvae occurred from June to August, being most common in July. In 1982 a few common carp larvae also appeared in April (Appendix 6). Common carp larvae had never been collected in the study area during preoperational years. During operational years, they were found mostly at Cook stations. Of the 23 samples containing common carp larvae, only two were collected at Warren Dunes. These data suggest that common carp spawning took place at Cook Plant stations during operational years and we attributed this to the warm water plume and currents produced by the heated discharge of the Cook Plant. Thus common carp spawning at the Cook Plant was a clear plant effect. Common carp larvae were collected at Warren Dunes at relatively low densities (31 larvae/1,000 m^3 and 83 larvae/1,000 m^3). These larvae may have drifted from the Cook Plant area. At Cook stations, densities of larvae were substantially higher in the beach zone than in open water (Appendices 4-6), suggesting that carp spawning probably took place mostly in shallow water. Common carp larvae ranged from 4.0 to 7.4 mm TL.

Common carp larvae were found in entrainment samples from 1976 to 1981. Entrainment estimates during this period (0.9 million larvae) were relatively low. Yearly entrainment estimates ranged from 0.02 million larvae in 1977 to 0.3 million larvae in 1979. During 1975 and 1982 common carp larvae were abundant in Lake Michigan, but were completely absent from entrainment samples. In contrast, some common carp larvae were entrained during 1977 and 1981 when none were caught at Lake Michigan stations. Common carp larvae were collected in

entrainment samples during June, July, and August. They were found in three samples in 1976, one sample in 1977, two samples in 1978, six samples in 1979, one sample in 1980, and three samples in 1981. Densities in a sample ranged from 11 to 66 larvae/1,000 m^3. A comparable density range (15 to 79 larvae/ 1,000 m^3) was observed in field samples collected at open water stations. Entrained carp larvae ranged from 4.1 to 7.6 mm TL. Few juveniles were collected, suggesting high mortality of common carp larvae.

Sculpins--

Slimy sculpin larvae were collected in Lake Michigan only during 1975, 1980, and 1982. All larvae were taken during June at open water stations (Appendices 4-6). Densities of larvae in a sample ranged from 17 to 44 larvae/1,000 m^3. More larvae were caught at Cook than at Warren Dunes stations, suggesting that rock riprap at the intake and discharge structures probably attracted spawning slimy sculpins. Slimy sculpin larvae were entrained every year except 1979. Estimated total entrainment of slimy sculpins was 2.5 million larvae during 1975-1982. Yearly entrainment estimates ranged from 0.02 million in 1977 to 1 million in 1981 (Table 13). Slimy sculpin larvae were entrained during June, July, and August. They measured from 6.0 to 9.3 mm TL.

Mottled sculpin larvae were never collected at Lake Michigan stations during 1973-1982. They were, however, entrained in all operational years except 1978 and 1980. Entrainment estimates for mottled sculpin larvae (1.1 million) were substantially lower than those for slimy sculpins. Mottled sculpin larvae were entrained only during May and June. Entrained larvae ranged from 6.0 to 9.2 mm TL.

Slimy sculpins and mottled sculpins are very similar in appearance as larvae and an accurate fin-ray count is essential to separate the two species correctly. Unidentified sculpin larvae were either slimy or mottled, but due either to their deteriorated physical condition or extremely early stage of development, they could not be identified with certainty. Unidentified sculpin larvae occurred in field samples only during 1978. They were found in entrainment samples every year during 1975-1982. Projected total entrainment of unidentified sculpin larvae was 2.5 million. Larvae were entrained during May, June, and July.

Deepwater sculpin larvae were caught at Lake Michigan stations during 1978-1981. They occurred only during April and May. All larvae we collected were taken in open water, with densities ranging from 17 to 65 larvae/1,000 m^3. Deepwater

sculpins were entrained only during 1978 and 1979. Projected entrainment for the 2 years was 0.19 million larvae. Entrainment of deepwater sculpins occurred during March and June.

Ninespine Stickleback--

Ninespine stickleback larvae were caught at Lake Michigan stations only during 1974. They occurred in entrainment samples in 1978, 1980, 1981, and 1982. The total entrainment estimate for ninespine stickleback was 0.6 million. Larvae were entrained from June to September.

Unidentified Minnows--

Unidentified minnow larvae were found in field samples only during 1978 and 1981. They occurred in entrainment samples during 1977 and 1979-1982. Projected total entrainment of unidentified minnow larvae was 2.4 million. Highest yearly entrainment (1 million larvae) was observed in 1982. Unidentified minnow larvae were entrained from April to August.

Miscellaneous Species--

Quillback larvae were caught in two field samples during May 1980 and in one field sample during June 1982. This species was entrained during April 1977 and May 1981. Total entrainment estimate for quillback larvae was 0.6 million. Unidentified coregonid larvae were collected in Lake Michigan samples during August 1978 and in entrainment samples during May 1977. Gizzard shad larvae occurred in field samples in July 1982, emerald shiner during July 1981, and unidentified sucker larvae during May 1978. Entrainment samples taken during 1975-1982, however, never contained these three species. An unidentified darter larva was entrained during June 1977.

FISH EGGS

Introduction

Fish eggs collected at the Cook Plant were not identified to species. However, the probable species composition of the eggs can be shown by their distribution and seasonal occurrence. Entrained fish eggs in January and February were probably those of burbot, which spawn in midwinter under the ice. Fish eggs were most abundant in June and July, and the predominant spawning fish then are alewife, spottail shiner, and yellow perch. Yellow perch eggs remain in a gelatinous mass on the lake bottom while

incubating, so we would not collect them in plankton net tows. Spottail shiner eggs are demersal and adhesive (Auer 1982) so we would be unlikely to collect them, except in beach tows when conditions were somewhat turbulent. Therefore, most eggs in our samples, and probably virtually all those taken in open water during summer, were those of alewife. Alewife eggs are somewhat demersal, but not so much as those of spottail shiner (Auer 1982), so they probably sink slowly enough to be collected by plankton nets. Some large fish eggs (few in number) entrained during October and November may have been those of trout or salmon, which spawn in the fall.

Analysis of variance was applied to fish egg data for entrainment samples (1975-1982), beach samples (1973-1982), and open water samples (1974-1982 - see METHODS - FIELD LARVAE - Statistical Analyses for details). Many interactions were significant in the field egg ANOVA, particularly those including Year. Significant interactions interfere with analysis; however, significant factors are reported here despite interactions.

Entrained Eggs

Annual Estimates--

Estimated entrainment loss of fish eggs was 3.335 billion during 1980, .996 billion during 1981, and 7.005 billion during 1982 (Table 13). Egg entrainment during 1980 and 1982 was higher than the 8-yr (1975-1982) average of 2.863 billion. The 1981 loss was below average and was the lowest since 1975. The 7 billion fish eggs estimated entrained in 1982 represented the highest yearly estimate of the 8 years of plant operation. June water volume pumped by the plant was higher in 1982 than other years (Table 14). As June is the month of peak fish egg densities, high pumping rates were most influential on estimates that month. Alewife larvae were fairly abundant in entrainment samples in 1982, but not as strikingly abundant as fish eggs, when year-to-year patterns are compared (Table 13).

Seasonal Abundance--

Fish eggs were entrained during most months, 1980-1982. Eggs entrained during January and February were probably burbot eggs and were usually few in number, except for 102 million estimated entrained during those months in 1982. Generally a few million eggs per month were entrained during early spring, with densities below 100 eggs/1,000 m^3. A notable exception was the period 3 April-3 May 1982 when 1.135 billion eggs were entrained and mean densities exceeded 1,000 eggs/1,000 m^3 several times. These were most likely rainbow smelt eggs. Peak egg entrainment

occurred during June 1980 (2.6 billion), 1981 (470 million), and 1982 (4.96 billion) (Tables 15-17). July egg entrainment was usually also high, 398 to 800 million. Mean egg densities often exceeded 10,000 eggs/1,000 m^3 during June and July (Tables 18-20). The highest individual sample density, 147,000 eggs/1,000 m^3, occurred during dusk to midnight, 1 July 1982. Densities over 90,000 eggs/1,000 m^3 were recorded several other times during 1980-1982. No eggs were entrained during September, but a few (less than 1 million per month) were entrained during October and November.

Diel Abundance--

More fish eggs were entrained at night than during the day, notably during the midnight to dawn period, when 50-65% were entrained over each year, 1980-1982. During the dusk to midnight period, 15% to 44% of the eggs were entrained. The ANOVA showed there were significant differences in egg densities among diel periods during 1982 alone and 1975-1982 combined ($p < 0.001$), but differences were not significant for 1980 ($p = 0.374$) or 1981 ($p = 0.021$) alone. The greatest mean densities of 1980 occurred 20-21 June and 14-15 July during midnight to dawn, 66,000 and 64,000 eggs/1,000 m^3, respectively. Peak egg abundance for 1981 occurred on 13-14 July, when the midnight to dawn mean was 48,000 eggs/1,000 m^3. The peak mean density for 1982 was 79,000 eggs/ 1,000 m^3 during dusk to midnight, 10-11 June. A mean of 67,000 eggs/1,000 m^3 occurred on 29 June-1 July 1982 (Tables 18-20). Patterns of diel abundance of fish eggs can be attributed to nocturnal spawning habits of alewife. Field-collected eggs increased in abundance from dusk to shortly after midnight; these were taken by plankton net throughout the water column. Alewives are pelagic spawners; their eggs sink, being slightly negatively buoyant. Thus alewife eggs would be entrained in the later part of the night. However, many eggs were entrained during the day, while few to none were ever collected in plankton nets towed during the day. Sled tows collect significantly more alewife eggs than do plankton net tows (Madenjian and Jude 1985). Divers often noted plumes of cold turbid water flowing along the bottom into the intakes on one side during certain times in summer, when the thermocline was far offshore (Dorr and Jude in press). We thus concluded that eggs that settled on the bottom were entering the intakes, increasing entrainment of these eggs over levels we would expect from plankton net densities.

Field-Collected Eggs

Seasonal Distribution--

Fish eggs were most abundant in field samples during June and July; they also occurred during April, May, August, and October 1980-1982 (Table 82). During early spring, eggs seldom occurred in open water. Both the number of samples containing eggs and densities of eggs increased sharply in June, usually decreasing somewhat in July and tapering off in August. No fish eggs were found in our samples during September or November 1980-1982, and only one October sample contained eggs. Peak sample densities (no./1,000 m^3) recorded for each month were: April - 476, May - 164, June - 70,160, July - 9,292, August - 1,212, and October - 66. Most of these peak densities were from beach samples during 1980 (Appendices 4-6). Results from 1980-1982 were similar to those observed in 1973-1979, with eggs occurring over a longer season in the beach zone than in open water (Bimber et al. 1984).

Diel Abundance--

Significantly more fish eggs were collected at night than during the day in the beach zone (Table 83). The vast majority of eggs taken in open water also occurred at night (Appendices 4-6). Since most fish eggs we collected were alewife eggs, alewife spawning habits explain the diel pattern of eggs: alewives are nocturnal spawners whose eggs are semi-demersal (Graham 1956; Mansueti and Hardy 1967). Thus alewife eggs could be collected by our gear at night, but most would have settled to the bottom by afternoon, when day sampling was conducted. Results for 1980-1982 are similar to our results from 1973-1979 (Bimber et al. 1984). During 1973-1979, egg abundance increased steadily from dusk to shortly after midnight, demonstrating increasing spawning activity. This pattern was also apparent in the 1980-1982 data.

Spatial Distribution--

Depth distribution-- Mean densities of fish eggs were usually higher in the beach zone than in open water during 1980-1982 (Table 82). This may be partly due to the demersal nature of the eggs, which would settle from the water column in open water, but could be resuspended in the beach zone and collected by our nets. Also, most spottail shiners spawn in the beach zone, thus more eggs may actually have been present. For 1974-1982, fish eggs were significantly more abundant at 6-m stations than at 9-m stations (Table 84).

Table 82. Mean densities (no. per 1,000 m^3) of fish eggs collected at all beach and openwater stations near the D. C. Cook Plant, 1980-1982. Day and night sampling periods were combined.

Month/ Sampling Area	Year 1980	1981	1982
April			
beach	40	31	0
open water	0	1	0
May			
beach	32	0	0
open water	0	0	1
June			
beach	8,366	4,074	1,206
open water	1,132	141	5
July			
beach	471	416	88
open water	307	1	153
August			
beach	0	12	212
open water	0	<1	<1
September			
beach	0	0	0
open water	0	0	
October			
beach	6	0	0
November			
beach	0	0	0

Cook Plant versus Warren Dunes-- The ANOVA showed significantly more fish eggs were collected at Cook Plant open water stations than at Warren Dunes reference stations (Table 84). However, abundance differences were a function of the time when samples were collected. We generally followed the same sequence, and Warren Dunes stations were nearly always sampled earlier during the night. Whichever area was sampled later

Table 83. Analysis of variance summary for log(catch + 1) of fish eggs. Eggs were netted in the beach zone during June to August 1973-1982 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df	Mean square	F-statistic	Attained significance
Year	9	17.1547	21.8920	<0.0001**
Month	2	84.1631	107.4053	<0.0001**
Station	2	8.1312	10.3766	0.0001**
Time	1	18.2278	23.2615	<0.0001**
Y x M	18	5.4986	7.0171	<0.0001**
Y x S	18	3.2049	4.0900	<0.0001**
M x S	4	1.7149	2.1885	0.0721
Y x T	9	9.1705	11.7030	<0.0001**
M x T	2	0.3156	0.4027	0.6691
S x T	2	1.1382	1.4525	0.2367
Y x M x S	36	3.3125	4.2273	<0.0001**
Y x M x T	18	8.2935	10.5839	<0.0001**
Y x S x T	18	1.9833	2.5310	0.0010**
M x S x T	4	1.0804	1.3787	0.2431
Y x M x S x T	36	1.5713	2.0053	0.0016*
Within cell error	180	0.7836		

** Highly significant (P < 0.001).
* Significant (P < 0.01).

generally had higher egg densities; sometimes no difference was apparent. In this respect, data from 1980-1982 showed the same trends as 1973-1979 (Bimber et al. 1984). June and July samples in 1980 and 1982 were collected first at Warren Dunes, then at the Cook Plant; egg densities were greater at Cook stations in those years. During 1981 June and July samples were collected first at the Cook Plant, then at Warren Dunes, and Warren Dunes egg densities were greater. Densities at beach station A (north Cook) were significantly greater than stations B (south Cook) or F (Warren Dunes); however, like open water data, these differences could not be attributed to the effect of the plant.

Vertical distribution--Distribution of fish eggs through the water column showed no consistent pattern. In 1980 and 1981, midwater densities were slightly higher than bottom densities, but in 1982, bottom plankton net tows collected more eggs (Appendices 4-6). Densities were highly variable, probably

Table 84. Analysis of variance summary for log(catch + 1) of fish eggs. Eggs were netted at night in the open water zone during June and July 1974-1982 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance
Year	8	8.9789	9.8882	<0.0001**
Month	1	26.3951	29.0683	<0.0001**
Area	1	61.4432	67.6660	<0.0001**
Depth	1	8.6772	9.5559	0.0022*
Y x M	8	3.2364	3.5642	0.0006**
Y x A	8	6.7545	7.4386	<0.0001**
M x A	1	0.3942	0.4341	0.5106
Y x D	8	1.3712	1.5101	0.1540
M x D	1	3.3958	3.7397	0.0543
A x D	1	0.4084	0.4498	0.5031
Y x M x A	8	2.3680	2.6079	0.0093*
Y x M x D	8	4.7260	5.2046	<0.0001**
Y x A x D	8	2.0749	2.2851	0.0224
M x A x D	1	3.5045	3.8594	0.0506
Y x M x A x D	8	1.8234	2.0081	0.0460
Within cell error	249	0.9080		

\# Thirty-nine degrees of freedom were subtracted from the error term to correct for 39 missing observations where the cell means were substituted.

† Mean squares were multiplied by harmonic mean cell size/maximum cell size (nh/n = 0.8496) to correct for 39 missing observations where the cell means were substituted.

** Highly significant (P < 0.001).

* Significant (P < 0.01).

because of patchy distribution of eggs due to spawning aggregations of fish. Bottom densities might be expected to be higher than upper strata densities due to demersal eggs. However, plankton net tows do not sample the lake bottom effectively and thus would miss the area of greatest egg abundance.

Field-Entrainment Comparison

Introduction--

We compared mean densities of fish eggs between field and entrainment samples. Field sample means were computed by taking means for each diel period (two) for stations C, D, and R (Cook) over all replicates (four at 6-m stations C and R, five at 9-m station D). Stations G and H (Warren Dunes) were omitted from the analysis because egg densities were usually much lower there than at the Cook Plant. Entrainment samples on the date nearest to field samples were used for comparisons (Table 85) to minimize changes in egg densities due to water mass exchange. The density computed for each diel division of entrainment sampling was the mean of four replicates. Density reported for each diel period (day or night) was the mean of two sets of samples (eight total), namely dusk-midnight and midnight-dawn for nighttime density and dawn-noon and noon-dusk for daytime density. Thus each diel comparison each month was based on 13 field and 8 entrainment samples. Exceptions were in June and August 1981 and July 1982, when the means of two entrainment sets (16 day samples, 16 night samples) were calculated because they were equidistant in time from field samples.

To compare annual trends in egg abundance between field and entrainment samples, we calculated mean density over the months May through August, using only entrainment densities on dates close to field sampling, as in the above comparison. We used Spearman rank correlation tests to compare abundance ranks of fish eggs in night field and entrainment samples. Rank correlation coefficients were computed by ranking mean densities each year, 1975-1982.

Seasonal Abundance--

Fish egg abundance patterns over the season were similar between entrainment and field samples, with the constraint that no field data were available during winter. Field and entrainment densities (1975-1982) were usually low in April and May, peaked in June or July, and decreased sharply through August, with a few eggs sometimes collected during the fall. However, mean densities did not always peak the same month for field and entrainment samples in a given year (Table 86; Bimber et al. 1984). In 1975, 1977, and 1982, field mean densities (day and night combined) were highest in July, and entrainment densities highest in June; in 1979 and 1980 entrainment egg means peaked in July while field densities peaked in June.

Table 85. Sampling dates used to compare field-caught and entrained eggs at the D. C. Cook Plant, May through August, 1980-1982. F = field, E = entrainment.

Month	Diel Period	1980 F	1980 E	1981 F	1981 E	1982 F	1982 E
May	day	13	13	13	12	11	11
	night	14-15	12	12-13	11	11	10
June	day	11	10	9	9,13	16	16-17
	night	11	9	10	8,12-13	16-17	16-17
July	day	8	15	7	2-3	20	20-23
	night	9	14-15	6	2-3	20-21	20-23
August	day	12	12	12	11,13-14	10	18-19
	night	12	11-12	12	10,13-14	10	18-19

Mean Density Comparison--

Mean densities of entrained fish eggs were nearly always greater than mean densities of field-collected eggs, 1975-1982 (Table 86; Bimber et al. 1984). Only in June 1979 was mean field density greater than mean entrainment density, and in that case field sampling occurred 6 days later than entrainment sampling. For both types of samples, night densities were nearly always greater than day densities, because of the nocturnal spawning habits of alewife, the main contributor to the eggs collected. Differences between field and entrainment densities were so marked, often orders of magnitude, that day entrainment densities frequently exceeded night field densities (Table 86; Appendices 1-6; Bimber et al. 1984).

Nighttime densities were used for comparisons between years. Mean densities of field-collected fish eggs were highest for 1979, followed by 1975 and 1980. Mean densities of entrained eggs were highest for 1978, followed by 1982 and 1980 (Table 86; Bimber et al. 1984). The Spearman rank correlation coefficient for field-collected vs. entrained egg densities ranked by year was 0.05, indicating no correlation.

Table 86. Mean monthly densities (no./1,000 m^3) of fish eggs in field (stations C, D, R) and entrainment samples at the D. C. Cook Plant, 1980-1982. Entr. = entrainment. N = number of samples included in mean.

Month	Sample Type	Diel Period	1980	1981	1982	N
May	Field	Day	0	0	0	13
		Night	0	0	4	13
	Entr.	Day	3	151	6	8
		Night	0	174	18	8
June	Field	Day	31	0	1	13
		Night	5,187	12	21	13
	Entr.	Day	13,538	1,563*	1,973	8
		Night	25,299	7,998*	64,236	8
July	Field	Day	0	0	2	13
		Night	1,416	4	702	13
	Entr.	Day	6,821	539	235**	8
		Night	37,003	1,102	3,513*	8
August	Field	Day	0	0	1	13
		Night	0	2	0	13
	Entr.	Day	0	18*	1	8
		Night	0	16*	0	8
Means	Field	Day	8	0	1	
		Night	1,651	4	182	
	Entr.	Day	5,090	568	554	
		Night	15,576	2,322	16,942	

* N = 16
** N = 15

The differences in magnitude and lack of yearly correlation between field and entrainment egg densities are probably primarily due to the demersal nature of fish eggs, coupled with

our sampling scheme. Plankton nets do not sample the bottom layer effectively, collecting only freshly released or resuspended eggs, thus biasing field densities downward (see Madenjian and Jude 1985). In contrast, the Cook Plant intake probably draws some cooling water from the bottom layer, where eggs collect. There are several items that provide evidence for this. Daytime sled tows on 18 June 1975 collected fish eggs at densities of 1,246, 6,839, and 21,399/1,000 m^3 at 18-, 15-, and 12-m stations respectively (unpublished data, Great Lakes Research Division, Univ. Mich., Ann Arbor, Mich. 48109), suggesting increasing egg densities with shallower water. Night sled tows had lower densities, probably because newly released eggs were still in midwater. Mean daytime density of entrained eggs was 1,885 eggs/1,000 m^3 on 17-19 June 1975, less than sled tows would probably have collected at the intake depth. Mean daytime egg density from net tows at Cook stations, June 1975, was only 60/1,000 m^3 (Bimber et al. 1984). Daytime field egg densities from standard series sampling were very low in proportion to night field densities. Night:day ratios of mean densities for 1975-1982 combined were 157:1 for field-collected and 4:1 for entrained eggs. Thus, field data imply most eggs were spawned at night and sank to the bottom before day sampling, while entrainment data suggest eggs could be drawn from the bottom layer during daytime. Eggs from the lake bottom also probably elevated night entrainment densities over night field densities.

ESTIMATION OF ALEWIFE SURVIVAL DURING THE FIRST GROWTH SEASON

Introduction

Alewife larvae are widely distributed throughout inshore waters (1-9-m depth contours) of southeastern Lake Michigan, at all depth strata (Jude et al. 1979b). Juveniles (20-40 mm) inhabit the beach zone (1-3 m) during late summer, then begin offshore movement around September. Those hatched earliest move offshore first (Brown 1972). Supplemental trawling conducted offshore from the D. C. Cook Plant in 1978 showed few alewives occupied areas beyond the 15-m depth contour in October. Similarly, in eastern Lake Michigan near the J.H. Campbell Plant, juvenile alewives were most abundant at 1-1.5 m during September and 3-12 m during October, and alewife larvae were usually widespread over 1-15-m depths during summer (Jude et al. 1982). Therefore abundance of larvae and juveniles at 6 and 9 m (data used in this study) is considered to be representative of the inshore abundance of alewives.

Many young of the year (YOY) concentrate in bottom layers during fall (Wells 1968, Brown 1972). Midwater trawling and acoustical scanning done simultaneously with bottom trawls in eastern Lake Michigan showed that few alewives of any size were at midlevels in the water column (Wells 1983). In western Lake Michigan, echosounding indicated that more fish were in the water column at night than during the day; also, more alewives were collected in bottom trawls during the day than at night (Janssen and Brandt 1980). Although YOY alewives may ascend in the water column during turbulence (Wells 1968) and at night (our data), they were consistently more abundant in day trawls than at night near the D. C. Cook Plant. By expressing our trawl catch as number of YOY per 1,000 m^3, these densities could be compared with densities of newly hatched larvae to yield survival estimates from hatching to the time of offshore movement during the first growth season. Hatch et al. (1981) and Argyle (1982) used similar methods to generate population estimates.

Results

During 2 years, 1977 and 1978, fish larvae densities in both field and entrainment collections were low and YOY densities high relative to other years (Table 87), resulting in improbably high survival rates (Table 88). During other years, using either entrainment or field fish larvae data, calculated survival from yolk-sac larvae to YOY was always below 2%. Mean densities of larval fish each year did not correlate well between field and entrainment samples, or between size groups within one type of

sample. The Spearman rank correlation among years for densities of 2-5 mm larvae between field and entrainment samples was 0.43. Rank correlations of densities for larger larvae between field and entrainment samples, and between size groups within one type of sample (field or entrainment), were all less than 0.7. The best correlation obtained (0.79) was between field and entrainment data for survival from yolk-sac larvae to YOY. Mean densities of 2-5-mm larvae over all years were similar between field and entrainment samples, 1,720 and 1,810 larvae/1,000 m^3 respectively (Table 87), resulting in similar calculated survival rates over the entire study, about 1% from yolk-sac larvae to YOY (Table 88).

As expected, survival from postlarvae to YOY (averaging 2%) was nearly always greater than from yolk-sac larvae to YOY (averaging 1% - Table 88). Higher mean survival from postlarvae to YOY (10-33%) was calculated for larvae from separate length intervals 5.5-10 mm, 10.5-15 mm, 15.5-20 mm, and 20.5-25 mm using entrainment data (Table 88). When all lengths 5.5-25 mm of entrained larvae were pooled, calculated survival was 5% from postlarvae to YOY (Table 88).

Daily mortality rates generally declined over time (Table 89). When rates increased, which only occurred for design I, it was thought to be an artifact derived from long intervals between peak catches of two successive length groups (e.g., 18 days between 2-5 and 5.5-10 mm, compared with a 7-day estimation using Heinrich's data). Sampling at discrete times, a week or a month apart, sometimes allows actual abundance peaks to be missed and biases estimates.

Highest daily mortality (27.3%) was found for entrained larvae which passed from the 2-5-mm group to the 5.5-10 mm group (design II; Table 89). Lowest daily mortalities, around 2%, occurred for larvae and juveniles >15.5 mm. Length partitioning of entrained larvae demonstrated this rapid change in mortality over time; the change was not so evident when the wider length intervals were used.

Young of the year were less abundant at lengths of 15 to 34 mm than at greater sizes, although abundance did not peak at the same size in every year (Fig. 21). Alewives 15-34 mm were concentrated in shallower water than trawl depths; many in this size range were taken in beach seines, particularly during August. Modal size of alewives in trawls was usually between 35 and 64 mm. Alewives 35 to 64 mm probably have not reached overwintering size, since yearlings collected in April tended to be larger (mean size about 90 mm). Therefore, survival rates in this study do not reflect the entire growth season.

Table 87. Densities (number/1,000 m^3) of various sizes of entrained and field-collected alewife larvae, and peak densities of YOY (young of the year) which were used to generate ratios in Table 88. ND = no data.

		Entrained Larvae (Length Interval - mm)						Field Larvae (Length Interval - mm)	
Year	YOY	2-5	5.5-10	10.5-15	15.5-20	20.5-25	5.5-25	2-5	5.5-25
1974	10.0	ND	ND	ND	ND	ND	ND	5,350	2,050
1975	14.0	4,040	75	18	39	12	144	2,790	782
1976	13.5	1,600	247	199	91	39	576	1,040	1,780
1977	28.1	1,200	273	114	52	6	445	294	475
1978	61.7	450	53	20	33	87	193	247	76
1979	14.2	1,580	456	180	179	187	1,000	3,180	351
1980	2.8	1,890	45	34	35	16	130	449	636
1981	2.5	2,110	130	54	64	78	326	675	316
1982	15.5	1,600	270	93	42	35	440	1,410	943
Means									
1974-1982	18.0							1,720	824
1975-1982	19.0	1,810	194	89	67	58	407		

Table 88. Survival rates: ratios of peak density of young-of-the-year alewives taken in trawls to densities of yolk-sac larvae and post-yolk-sac larvae, which were derived from entrainment and field collections each year. ND = no data. Values >1 indicate calculated survival >100%.

Year	Entrained Larvae (Length Interval - mm)						Field Larvae (Length Interval - mm)	
	2-5	5.5-10	10.5-15	15.5-20	20.5-25	5.5-25	2-5	5.5-25
1974	ND	ND	ND	ND	ND	ND	0.002	0.005
1975	0.003	0.186	0.775	0.358	>1	0.097	0.005	0.018
1976	0.008	0.055	0.068	0.149	0.347	0.024	0.013	0.008
1977	0.023	0.103	0.247	0.541	>1	0.063	0.096	0.059
1978	0.137	>1	>1	>1	0.709	0.320	0.250	0.806
1979	0.009	0.031	0.079	0.079	0.076	0.014	0.004	0.040
1980	0.001	0.063	0.083	0.081	0.176	0.022	0.006	0.004
1981	0.001	0.019	0.045	0.038	0.031	0.008	0.004	0.008
1982	0.010	0.057	0.167	0.368	0.440	0.035	0.011	0.016
Means (from density means)	0.011	0.098	0.214	0.285	0.331	0.047	0.011	0.022

Table 89. Percent daily mortality calculated from mean densities over all years, 1975-1982 (entrained) and 1974-1982 (field-caught). Design I used time intervals corresponding to peak occurrence of fish larvae of each length interval in our samples. Design II time intervals were calculated from alewife growth rates in the laboratory (Heinrich 1981). YOY = young of the year.

Length Interval (mm)	Entrained Larvae		Field-caught Larvae	
	design I	design II	design I	design II
2-5 to 5.5-10	11.7	27.3		
5.5-10 to 10.5-15	19.5	8.3		
10.5-15 to 15.5-20	3.5	4.0		
15.5-20 to 20.5-25	1.5	2.0		
20.5-25 to YOY	2.4	2.0		
2-5 to 5.5-25	5.7	12.7	3.1	6.4
5.5-25 to YOY	5.1	4.1	5.7	4.8
2-5 to YOY	5.3	5.3	5.0	5.0

Discussion

Yearly mean densities and survival of alewife were not good predictors of year-class strength as measured by our data. Spring trawl catches of yearling alewife bore no relationship to larvae or young-of-the-year densities the previous year. Spearman rank correlations among years were all less than 0.5. Yearling alewives tend to inhabit midwater more than young-of-the-year do (Brown 1972), making bottom trawls unreliable estimators of yearling abundance and probably partly accounting for lack of correlation.

Adult alewives collected at Cook were not aged. Our catches in gill nets, trawls, and seines represented several age-groups, age 2 and older. Therefore, yearly densities and survival of first-year fish could not be related to yearly recruitment to the adult population.

Variation in yearly survival estimates may be due to either true survival differences or incorrect assumptions. Alewife survival is certainly not the same each year, as temperature, food availability, abundance of predators, and other conditions fluctuate irregularly and affect alewife survival. The high survivals calculated for 1977 and 1978 can be attributed to the

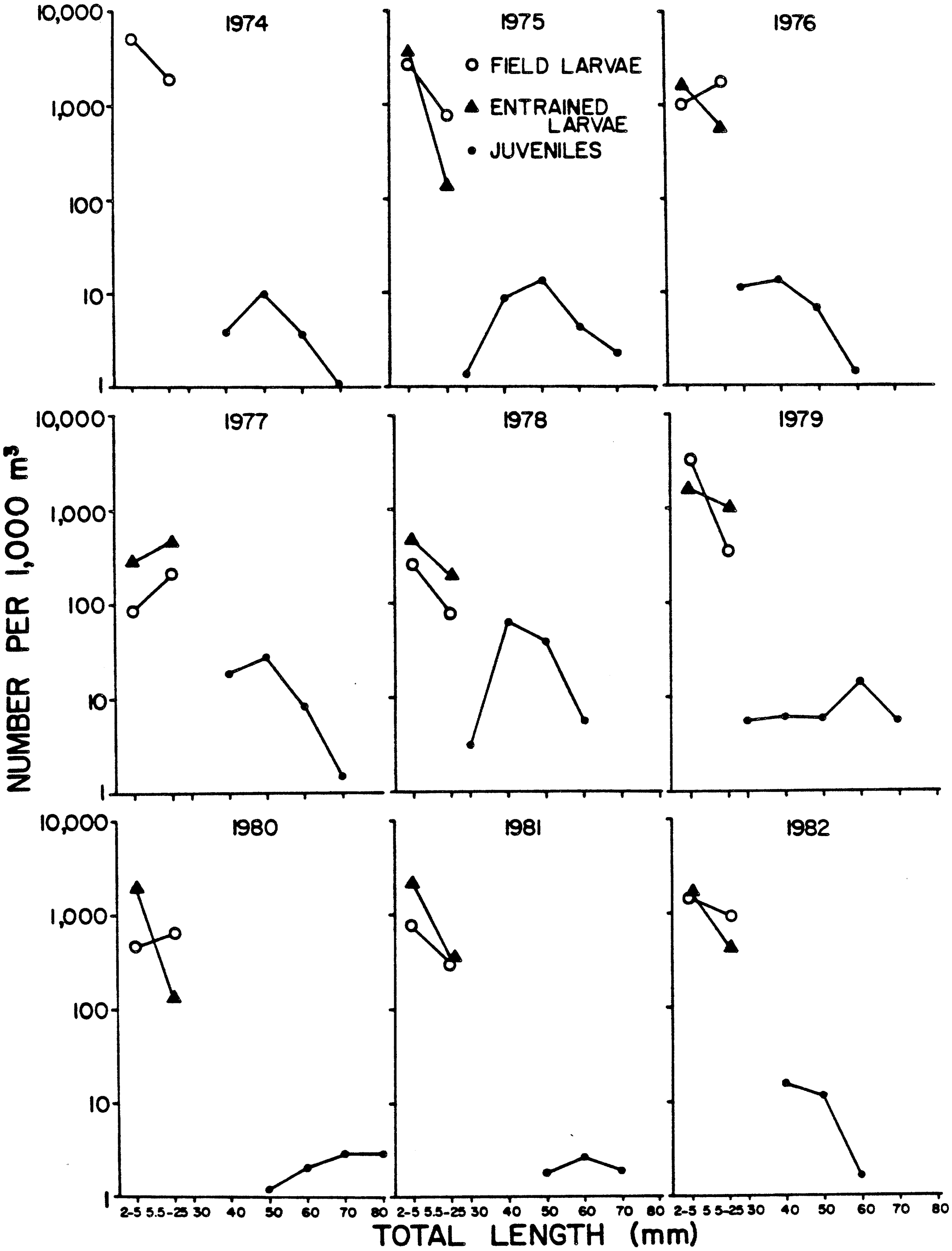


Figure 21. Catch curves for larval (2-5 mm and 5.5-25 mm) and young-of-the-year alewives collected near the D. C. Cook Plant, 1974-1982.

sampling schedule missing times of peak larvae abundance, or spawning and hatching taking place outside of the study area and juveniles moving into the area later (YOY collected by trawl). Either may occur fairly often, although weekly entrainment sampling is less likely to miss a hatching peak than is monthly field larvae sampling.

During a year of frequent and prolonged upwellings of cold water in eastern Lake Michigan, relatively few alewife larvae >5 mm were collected from 1-15-m depths, compared to larvae sampled during years of few upwellings (Heufelder et al. 1982). Upwellings may result in increased mortality to larvae or may displace larvae from the inshore zone (Heufelder et al. 1982). Thus differences in calculated survivals of post-yolk-sac larvae from year to year may be due to actual mortality differences or may be due to changes in distribution of older larvae from water mass movement. Yolk-sac larvae densities also may be depressed by direct mortality from upwellings or by transport through water mass movement. However, occurrence of newly hatched larvae was prolonged into September during a year of severe upwellings (Heufelder et al. 1982), possibly compensating for decreased densities (greater mortality or transport) by increased duration of occurrence (longer spawning season). Thus, yolk-sac larvae to YOY survival rates are apt to be less variable than post-yolk-sac larvae to YOY survival rates.

Other sources of variation which could influence survival rates include changes in trawling speed (thus distance trawled) and changes in trawl size, which can occur if trawling speed, currents or length of warp (line from boat to trawl) varies. Turbidity, illumination, and currents can affect net avoidance or escape of either larvae or YOY. Since trawl size was estimated, not measured, this was a possible source of error. Finally, the assumption that all YOY were near bottom may be wrong, but we have no concurrent midwater trawl data. Janssen and Brandt (1980) and Wells (1983) suggest that few alewives occupy midlevels during the day. If a significant proportion of the YOY were in midwater during the day, real survival rates would be higher than those reported here. Trawl size estimation may err in the opposite direction. Our trawl may not open as high as Hatch's, resulting in calculated YOY densities (and survival rates) being higher than actual values due to the trawl height factor in the adjustment of densities to the whole water column.

The "critical period" hypothesis, that the transition from yolk-sac larva to exogenous feeding is a time of high mortality (Hjort 1914, May 1974), is supported by our data. Survival from yolk-sac larva to post-yolk-sac larva is much lower than post-yolk-sac to YOY. The difference between entrainment and field data in post-yolk-sac to YOY survival may be due to entrainment sampling methods (pump or intake avoidance) or due to length-

interval partitions. If post-yolk-sac larvae are not separated into length intervals, this may result in artificially high densities because larvae of a given age may be vulnerable to sampling at successive sampling periods. If length intervals chosen are too small for sampling intervals, too low densities result (Farris 1960). Thus growth rates become a factor in the analysis, and post-yolk-sac larvae to YOY (age-specific) survival rates are more tentative than yolk-sac to YOY. Variations in growth rates over age, and between individual fish, result in apparent increases in survival and uncertainty as to correlation of age with length.

The daily mortality rates we calculated were comparable to those of other Clupeidae. Our daily mortalities from design II (Table 89) were similar to those found by Crecco et al. (1983) for American shad (*Alosa sapidissima*): 19.8-25.6% mortality per day for first-feeding American shad larvae, 4.3-8.7% for larvae approaching metamorphosis, and 1.8-2.0% for juveniles, while our alewife daily mortalities were 27.3%, 4.0-8.3%, and 2.0% for respective stages. Pacific herring (*Clupea pallasii*) larvae raised in enclosures showed a slightly different pattern (Schnack 1981). Although yolk absorption occurred at about 7 days after hatching, mortality was only 3-8%/day for the first 13-21 days, increasing to 20-30%/day for about a week following. Schnack attributed the increased mortality to starvation following yolk absorption. After 31-36 days from hatching, mortality decreased to 5-13%/day. Daily mortalities of round herring (*Etrumeus teres*), thread herring (*Opisthonema oglinum*), and scaled sardine (*Harengula jaguana*) for larvae 3-5 to 16-20 mm, were about 10%, 20%, and 22% respectively (Houde 1977a, 1977b, 1977c), higher than for alewife. Dragesund and Nakken (1971) found 94% mortality of Atlantic herring (*Clupea harengus*) during yolk absorption, between the 10- and 12-mm size groups. Pacific herring had 20-30% mortality per day over the first 20 days (Stevenson 1962). Survival curves for various herring differ regarding the presence and timing of a critical period (Dahlberg 1979).

We feel the truest representation of survival in this analysis is the ratio of density of yolk-sac larvae to density of YOY in the modal-length interval. Less abundant fish in certain length intervals of YOY represent fish that were more abundant at other depth contours than trawl depths, and density of older larvae is suspect due to growth rate uncertainty and variations in distribution.

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APPENDICES

Appendix 1. Densities (no./1000 m³) for fish eggs and larvae entrained at the D.C. Cook Plant, southeastern Lake Michigan, 1980. Sample parameter codes are: Mpd (month period): consecutive number of the sample period during the annual sample program. Ser (series): (1) standard series, (2) supplemental sample, (3) problems-sample not used in calculations. Grt (grate): location of forebay grate, see Fig. 3 for reference. N/S (north/south): further designation of sampling location at each grate, (1) north, (2) south, (3) no designation, see Fig. 3 for reference. Dpt (depth): depth (m) of sampling in the forebay. Dl (diel): (N1) midnight to dawn, (D1) dawn to noon, (D2) noon to dusk, (N2) dusk to midnight, (LD and LN) long day or long night, samples extending beyond normal diel schedule, (OD and ON) other day or other night, sampling was performed at irregular intervals. Temp: temperature (C) of intake water when the sample was collected. Refer to Table 12 for species designation. Blank entries indicate zero densities.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
1-21-80	1	1	3	1	5	N1	0.3																				0	0
1-21-80	1	1	3	2	5	N1	0.9																				0	0
1-21-80	1	1	2	3	5	N1	1.2																				0	0
1-21-80	1	1	9	3	5	N1	0.8																				0	0
1-22-80	1	1	3	1	5	N2	0.0																				0	0
1-22-80	1	1	3	2	5	N2	0.8																				0	0
1-22-80	1	1	2	3	5	N2	0.8																				0	0
1-22-80	1	1	9	3	5	N2	0.4																				0	0
1-22-80	1	1	3	1	5	D1	0.0																				0	0
1-22-80	1	1	3	2	5	D1	1.0																				0	0
1-22-80	1	1	2	3	5	D1	0.8																				0	0
1-22-80	1	1	9	3	5	D1	0.5																				0	0
1-22-80	1	1	3	1	5	D2	0.0																				0	0
1-22-80	1	1	3	2	5	D2	1.0																				0	0
1-22-80	1	1	2	3	5	D2	0.6																				0	0
1-22-80	1	1	9	3	5	D2	0.4																				0	0
1-28-80	2	1	3	1	5	N1	2.8																				0	0
1-28-80	2	1	3	2	5	N1	2.8																				0	0
1-28-80	2	1	2	3	5	N1	3.2																				0	0
1-28-80	2	1	9	3	5	N1	2.9																				0	0
1-29-80	2	1	3	1	5	N2	2.2																				0	0
1-29-80	2	1	3	2	5	N2	2.3																				0	0
1-29-80	2	1	2	3	5	N2	2.2																				0	0
1-29-80	2	1	9	3	5	N2	2.2																				0	0
1-30-80	2	1	3	1	5	D1	2.3																				0	0
1-30-80	2	1	3	2	5	D1	2.3																				0	0
1-29-80	2	1	2	3	5	D1	0.8																				0	0
1-29-80	2	1	9	3	5	D1	0.8																				0	0
1-30-80	2	1	3	1	5	D2	3.5																				0	0
1-30-80	2	1	3	2	5	D2	3.6																				0	0
1-29-80	2	1	2	3	5	D2	2.3																				0	0
1-29-80	2	1	9	3	5	D2	2.3																				0	0
1-30-80	2	2	8	3	5	D1	2.3																				0	0

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
1-30-80	2	2	8	3	5	D2	3.5																				0	0
2-04-80	3	1	3	1	5	N1	0.5																				0	0
2-04-80	3	1	3	2	5	N1	0.4																				0	0
2-04-80	3	1	2	3	5	N1	0.5																				0	0
2-04-80	3	2	8	3	5	N1	0.4																				0	0
2-04-80	3	1	3	1	5	N2	0.7																				0	0
2-05-80	3	1	3	2	5	N2	2.5																				0	0
2-05-80	3	1	2	3	5	N2	3.0																				0	0
2-05-80	3	2	8	3	5	N2	2.1																				0	0
2-05-80	3	1	3	1	5	D1	5.8																				0	0
2-05-80	3	1	3	2	5	D1	5.0																				0	0
2-05-80	3	1	2	3	5	D1	5.5																				0	0
2-05-80	3	2	8	3	5	D1	5.4																				0	0
2-05-80	3	1	3	1	5	D2	2.4																				0	0
2-05-80	3	1	3	2	5	D2	3.5																				0	0
2-05-80	3	1	2	3	5	D2	3.0																				0	0
2-05-80	3	2	8	3	5	D2	3.0																				0	0
2-19-80	4	1	3	1	5	N1	1.0																				0	0
2-19-80	4	3	3	2	5	N1	1.0																				0	0
2-19-80	4	1	2	3	5	N1	1.0																				0	0
2-19-80	4	1	9	3	5	N1	1.0																				0	0
2-20-80	4	1	3	1	5	N2	1.0																				0	0
2-20-80	4	1	3	2	5	N2	1.0																				0	0
2-20-80	4	1	2	3	5	N2	1.0																				0	0
2-20-80	4	1	9	3	5	N2	1.0																				0	0
2-20-80	4	1	3	1	5	D1	1.0																				0	0
2-20-80	4	1	3	2	5	D1	1.0																				0	0
2-20-80	4	1	2	3	5	D1	1.0																				0	0
2-20-80	4	1	9	3	5	D1	1.0																				0	0
2-19-80	4	1	3	1	5	D2	1.0																				0	0
2-19-80	4	1	3	2	5	D2	1.0																				0	0
2-19-80	4	1	2	3	5	D2	1.0																				0	0
2-19-80	4	1	9	3	5	D2	1.0																				0	15
3-10-80	5	1	3	1	5	N1	4.6																				0	0
3-10-80	5	1	3	2	5	N1	4.2																				0	0
3-10-80	5	1	2	3	5	N1	3.0																				0	0
3-10-80	5	1	9	3	5	N1	3.9																				0	0
3-11-80	5	1	3	1	5	N2	7.2																				0	0
3-11-80	5	1	3	2	5	N2	7.0																				0	0
3-11-80	5	1	2	3	5	N2	7.3																				0	0

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
3-11-80	5	1	9	3	5	N2	7.2																				0	0
3-11-80	5	1	3	1	5	D1	7.0																				0	0
3-11-80	5	1	3	2	5	D1	6.0																				0	0
3-11-80	5	1	2	3	5	D1	5.8																				0	0
3-11-80	5	1	9	3	5	D1	6.3																				0	0
3-11-80	5	1	3	1	5	D2	6.0																				0	0
3-11-80	5	1	3	2	5	D2	5.5																				0	0
3-11-80	5	1	2	3	5	D2	5.7																				0	0
3-11-80	5	3	9	3	5	D2	5.7																				0	0
3-26-80	6	1	3	1	5	N1	1.0																				0	0
3-26-80	6	1	3	2	5	N1	2.0																				0	0
3-26-80	6	1	2	3	5	N1	1.0																				0	0
3-26-80	6	1	9	3	5	N1	1.3																				0	0
3-27-80	6	1	3	1	5	N2	1.0																				0	0
3-27-80	6	1	3	2	5	N2	1.0																				0	0
3-27-80	6	1	2	3	5	N2	1.0																				0	0
3-27-80	6	1	9	3	5	N2	1.0																				0	1196
3-27-80	6	1	3	2	5	D1	3.0																				0	0
3-27-80	6	1	2	3	5	D1	2.0																				0	0
3-27-80	6	1	9	3	5	D1	2.6																				0	0
3-27-80	6	1	3	1	5	D2	6.7																				0	23
3-27-80	6	1	3	2	5	D2	6.9																				0	0
3-27-80	6	1	2	3	5	D2	4.9																				0	0
3-27-80	6	1	9	3	5	D2	6.9																				0	0
4-07-80	7	1	3	1	5	N1	4.0																				0	0
4-07-80	7	1	3	2	5	N1	4.0																				0	0
4-07-80	7	1	2	3	5	N1	4.0																				0	0
4-07-80	7	1	9	3	5	N1	4.0																				0	0
4-07-80	7	1	3	1	5	N2	4.2																				0	0
4-07-80	7	1	3	2	5	N2	4.3																				0	0
4-07-80	7	1	2	3	5	N2	5.0																				0	0
4-07-80	7	1	9	3	5	N2	4.5																				0	0
4-08-80	7	1	3	1	5	D1	6.7																				0	0
4-08-80	7	1	3	2	5	D1	7.2																				0	0
4-08-80	7	1	2	3	5	D1	7.0																				0	0
4-08-80	7	1	9	3	5	D1	6.9																				0	0
4-08-80	7	1	3	1	5	D2	6.5																				0	0
4-08-80	7	1	3	2	5	D2	7.0																				0	0
4-08-80	7	1	2	3	5	D2	6.8																				0	0
4-08-80	7	1	9	3	5	D2	6.7																				0	0

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
4-22-80	8	1	3	2	5	N1	9.0																				0	0
4-22-80	8	1	3	1	5	N1	9.0																				0	0
4-22-80	8	1	2	3	5	N1	9.0																				0	0
4-22-80	8	1	9	3	5	N1	9.0																				0	0
4-23-80	8	1	3	2	5	N2	8.0																				0	0
4-23-80	8	1	3	1	5	N2	8.0																				0	23
4-23-80	8	1	2	3	5	N2	8.0																				0	0
4-23-80	8	1	9	3	5	N2	8.0																				0	18
4-22-80	8	1	9	3	5	D1	7.5																				0	0
4-22-80	8	2	8	3	5	D1	7.5																				0	200
4-22-80	8	1	3	2	5	D1	7.5																				0	0
4-22-80	8	1	3	1	5	D1	7.5																				0	0
4-22-80	8	1	2	3	5	D1	7.5																				0	34
4-22-80	8	1	3	2	5	D2	8.0																				0	33
4-22-80	8	1	3	1	5	D2	8.0																				0	53
4-22-80	8	1	2	3	5	D2	8.0																				0	0
4-22-80	8	1	9	3	5	D2	8.0																				0	28
4-21-80	8	2	8	3	5	N1	11.0																				0	30
4-22-80	8	2	8	3	5	N2	11.0																				0	18
4-22-80	8	1	9	3	5	N2	11.0																				0	18
5-12-80	9	1	3	1	5	N1	12.2			90																	90	0
5-12-80	9	1	3	2	5	N1	11.8																				0	0
5-12-80	9	1	2	3	5	N1	11.4																				0	0
5-12-80	9	1	9	3	5	N1	11.8																				0	0
5-12-80	9	1	3	1	5	N2	12.5			19												19					38	0
5-12-80	9	1	3	2	5	N2	12.9			312																	312	0
5-12-80	9	1	2	3	5	N2	12.7			99																	99	0
5-12-80	9	1	9	3	5	N2	12.7			51																	51	0
5-13-80	9	1	3	1	5	D1	13.2							27													27	0
5-13-80	9	1	3	2	5	D1	13.3			86																	86	0
5-13-80	9	1	2	3	5	D1	12.7			18																	18	0
5-13-80	9	1	9	3	5	D1	13.1			38																	38	0
5-13-80	9	1	3	1	5	D2	13.8			30												15					45	0
5-13-80	9	1	3	2	5	D2	14.3			81																	81	0
5-13-80	9	1	2	3	5	D2	13.8				11																11	11
5-13-80	9	1	9	3	5	D2	14.0																				0	10
5-29-80	10	1	3	1	5	N1	16.0																				0	98
5-29-80	10	1	3	2	5	N1	16.0																				0	0
5-29-80	10	1	2	3	5	N1	16.0																				0	50
5-29-80	10	3	9	3	5	N1	16.0																				0	0

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
5-30-80	10	1	3	1	5	N2	14.5																				0	83
5-30-80	10	1	3	2	5	N2	14.5								36												36	0
5-30-80	10	1	2	3	5	N2	14.5							34													34	104
5-30-80	10	1	9	3	5	N2	14.5																				0	75
5-30-80	10	1	3	1	5	D1	15.0																				0	0
5-30-80	10	1	3	2	5	D1	15.0																				0	34
5-30-80	10	1	2	3	5	D1	15.0																				0	67
5-30-80	10	1	9	3	5	D1	15.0																				0	0
5-29-80	10	1	3	1	5	D2	15.0							13													13	0
5-29-80	10	1	3	2	5	D2	15.0																				0	0
5-29-80	10	1	2	3	5	D2	15.0																				0	0
5-29-80	10	1	9	3	5	D2	15.0							10													10	0
6-06-80	11	1	3	2	5	D2	14.0																				0	151
6-06-80	11	1	3	1	5	D2	14.0																				0	49
6-06-80	11	1	2	3	5	D2	14.0																				0	0
6-06-80	11	1	9	3	5	D2	14.0																				0	74
6-06-80	11	1	3	2	5	N1	14.0								42												42	128
6-06-80	11	1	3	1	5	N1	14.0								29												29	89
6-06-80	11	1	2	3	5	N1	14.0																				0	0
6-06-80	11	1	9	3	5	N1	14.0																				0	105
6-07-80	11	1	3	2	5	N2	14.0		30																		30	862
6-07-80	11	1	3	1	5	N2	14.0																				0	120
6-07-80	11	1	2	3	5	N2	14.0																				0	892
6-07-80	11	1	9	3	5	N2	14.0																				0	328
6-07-80	11	1	3	2	5	D1	14.0			24																	24	498
6-07-80	11	1	3	1	5	D1	14.0																				0	167
6-07-80	11	1	2	3	5	D1	14.0				24																24	535
6-07-80	11	1	9	3	5	D1	14.0																				0	772
6-09-80	12	1	3	1	5	N1	15.0																				0	15026
6-09-80	12	1	3	2	5	N1	15.3				53			53													106	8074
6-09-80	12	1	2	3	5	N1	15.8		35		35				70												140	10391
6-09-80	12	1	9	3	5	N1	15.4				46				46												92	11158
6-09-80	12	1	3	1	5	N2	14.0	15				15										15					45	51174
6-09-80	12	1	3	2	5	N2	14.5															20					20	17496
6-09-80	12	1	2	3	5	N2	14.8																				0	32494
6-09-80	12	1	9	3	5	N2	14.6				30				15												45	56577
6-10-80	12	1	3	1	5	D1	13.6																				0	9147
6-10-80	12	1	3	2	5	D1	14.2																				0	15018
6-10-80	12	1	2	3	5	D1	14.2																				0	21963
6-10-80	12	1	9	3	5	D1	14.0																				0	33629
6-10-80	12	1	3	1	5	D2	13.8																				0	3859

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
6-10-80	12	1	3	2	5	D2	14.1				14																14	7826
6-10-80	12	1	2	3	5	D2	14.2							9													9	5034
6-10-80	12	1	9	3	5	D2	14.0																				0	11825
6-20-80	13	1	3	1	5	D2	16.5	230	86																		316	5013
6-20-80	13	1	3	2	5	D2	16.5	230	23					23													276	7410
6-20-80	13	1	2	3	5	D2	16.5		14																		14	1008
6-20-80	13	2	8	3	5	D2	16.5	48	145	32				80													305	4634
6-20-80	13	1	3	1	5	N1	17.0		26		26																52	33471
6-20-80	13	1	3	2	5	N1	17.0	42	427	42	42																553	50008
6-20-80	13	1	2	3	5	N1	17.0	101	177	25		25		25									75				428	36382
6-20-80	13	2	8	3	5	N1	17.0	213	294			78		187													772	43099
6-21-80	13	1	3	1	5	N2	17.0	142	14																		156	59311
6-21-80	13	1	3	2	5	N2	17.0			52				26													78	85275
6-21-80	13	1	2	3	5	N2	17.0	68	13	52																	133	53085
6-21-80	13	2	8	3	5	N2	17.0	76	30					15													121	66320
6-21-80	13	1	3	1	5	D1	16.0																				0	7413
6-21-80	13	1	3	2	5	D1	16.0	336		67								134									537	15485
6-21-80	13	1	2	3	5	D1	16.0	91			30																121	3869
6-21-80	13	2	8	3	5	D1	16.0	193																			193	4334
6-25-80	14	1	3	1	5	N1	18.0																				0	2512
6-25-80	14	1	3	2	5	N1	18.0	246																			246	6814
6-25-80	14	1	2	3	5	N1	18.0			29				29													58	5224
6-25-80	14	1	9	3	5	N1	18.0	99																			99	3182
6-26-80	14	1	3	1	5	N2	18.5	214	21					43													278	11070
6-26-80	14	1	3	2	5	N2	18.5	109																			109	16495
6-26-80	14	1	2	3	5	N2	18.5																				0	12342
6-26-80	14	1	9	3	5	N2	18.5	21		42				21													84	12553
6-26-80	14	1	3	1	5	D1	19.0	532																			532	2545
6-26-80	14	1	3	2	5	D1	19.0	144																			144	6666
6-26-80	14	1	2	3	5	D1	19.0	42		14																	56	1358
6-26-80	14	1	9	3	5	D1	19.0	93		15				30													138	1744
6-26-80	14	1	3	1	5	D2	19.0	596																			596	233
6-26-80	14	1	3	2	5	D2	19.0	165						54													219	639
6-26-80	14	1	2	3	5	D2	19.0	115																			115	298
6-26-80	14	1	9	3	5	D2	19.0			16																	16	306
7-14-80	15	1	3	1	5	N1	23.2	4415	1209					71													5695	9901
7-14-80	15	1	3	2	5	N1	23.0	2717	887					365													3969	7061
7-14-80	15	1	2	3	5	N1	23.5	3906	1364					62													5332	9982
7-14-80	15	1	9	3	5	N1	22.1	5154	1550		50			550													7304	13367
7-15-80	15	1	3	1	5	N2	22.0	176	679								25										880	63439

Appendix 1. Continued.

	Sample parameters							Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
7-15-80	15	1	3	2	5	N2	22.0	2208	1993					409													4610	66988
7-15-80	15	1	2	3	5	N2	22.4	1407	2710					677													4794	68653
7-15-80	15	1	9	3	5	N2	22.1	352	1169																		1521	56630
7-15-80	15	1	3	1	5	D1	23.2	901																			901	13367
7-15-80	15	1	3	2	5	D1	21.3	1998	70		23			261													2352	13243
7-15-80	15	1	2	3	5	D1	23.0	1273						70													1343	9343
7-15-80	15	1	9	3	5	D1	22.5	73						244													317	4624
7-15-80	15	1	3	1	5	D2	23.5	241						32									16				289	4399
7-15-80	15	1	3	2	5	D2	23.5	407	14																		421	4620
7-15-80	15	1	2	3	5	D2	23.8	301	35																		336	2610
7-15-80	15	1	9	3	5	D2	23.6	204	24					12													240	2360
7-24-80	16	1	3	2	5	N1	20.0			70																	70	35
7-24-80	16	1	3	1	5	N1	20.0																				0	131
7-24-80	16	1	2	3	5	N1	20.0	130																			130	87
7-24-80	16	2	8	3	5	N1	20.0	283																			283	63
7-25-80	16	1	3	2	5	N2	19.5	225										50									275	5514
7-25-80	16	1	3	1	5	N2	19.5	32																			32	3225
7-25-80	16	3	2	3	5	N2	19.5																				0	2642
7-25-80	16	2	8	3	5	N2	19.5	69																			69	2390
7-25-80	16	1	3	2	5	D1	21.0	34																			34	572
7-25-80	16	1	3	1	5	D1	21.0	22																			22	320
7-25-80	16	3	2	3	5	D1	21.0																				0	1485
7-25-80	16	2	8	3	5	D1	21.0	32																			32	303
7-25-80	16	1	3	2	5	D2	22.0	57																			57	133
7-25-80	16	1	3	1	5	D2	22.0	19																			19	58
7-25-80	16	1	2	3	5	D2	22.0																				0	76
7-25-80	16	2	8	3	5	D2	22.0																				0	83
7-30-80	17	1	3	2	5	N2	21.0	20																			20	225
7-30-80	17	1	3	1	5	N2	21.0	62																			62	158
7-30-80	17	1	2	3	5	N2	21.0	50																			50	127
7-30-80	17	2	8	3	5	N2	21.0	54																			54	660
7-30-80	17	1	3	2	5	D1	20.5																				0	110
7-30-80	17	1	3	1	5	D1	20.5	132																			132	44
7-30-80	17	1	2	3	5	D1	20.5																				0	62
7-30-80	17	2	8	3	5	D1	20.5																				0	84
7-30-80	17	1	3	2	5	D2	21.0																				0	70
7-30-80	17	1	3	1	5	D2	21.0																				0	0
7-30-80	17	1	2	3	5	D2	21.0																				0	16
7-30-80	17	2	8	3	5	D2	21.0																				0	0
7-30-80	17	1	3	2	5	N1	21.0	34																			34	69
7-30-80	17	1	3	1	5	N1	21.0																				0	0

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
7-30-80	17	1	2	3	5	N1	21.0																				0	0
7-30-80	17	2	8	3	5	N1	21.0	70						35													105	0
8-06-80	18	1	3	2	5	N1	23.5	32															32				64	0
8-06-80	18	1	3	1	5	N1	23.5	80				40															120	0
8-06-80	18	1	2	3	5	N1	23.5																				0	0
8-06-80	18	2	8	3	5	N1	23.5																				0	0
8-07-80	18	1	3	2	5	N2	24.0	19																			19	0
8-07-80	18	1	3	1	5	N2	24.0																				0	0
8-07-80	18	1	2	3	5	N2	24.0																				0	0
8-07-80	18	2	8	3	5	N2	24.0	20																			20	0
8-07-80	18	1	3	2	5	D1	23.5																				0	0
8-07-80	18	1	3	1	5	D1	23.5	24																			24	0
8-07-80	18	1	2	3	5	D1	23.5	28																			28	56
8-07-80	18	2	8	3	5	D1	23.5																				0	0
8-07-80	18	1	3	2	5	D2	24.0	45						15													60	219
8-07-80	18	1	3	1	5	D2	24.0																				0	123
8-07-80	18	1	2	3	5	D2	24.0	46																			46	94
8-07-80	18	2	8	3	5	D2	24.0	34																			34	0
8-11-80	19	1	3	2	5	N1	24.1																				0	0
8-11-80	19	1	3	1	5	N1	23.8	47																			47	0
8-11-80	19	1	2	3	5	N1	23.8																				0	0
8-11-80	19	1	9	3	5	N1	23.9																				0	0
8-12-80	19	1	3	2	5	N2	22.3	80																			80	0
8-12-80	19	1	3	1	5	N2	23.0	60																			60	0
8-12-80	19	1	2	3	5	N2	22.5																				0	0
8-12-80	19	1	9	3	5	N2	22.6	45																			45	0
8-12-80	19	1	3	2	5	D1	23.9	22																			22	0
8-12-80	19	1	3	1	5	D1	23.8	81																			81	0
8-12-80	19	1	2	3	5	D1	23.3	21																			21	0
8-12-80	19	1	9	3	5	D1	23.8																				0	0
8-12-80	19	1	3	2	5	D2	23.8	12																			12	0
8-12-80	19	1	3	1	5	D2	23.0	22																			22	0
8-12-80	19	1	2	3	5	D2	22.6	11																			11	0
8-12-80	19	1	9	3	5	D2	23.1	26																			26	0
8-21-80	20	1	3	2	5	N1	14.0																				0	0
8-21-80	20	1	3	1	5	N1	14.0																				0	0
8-21-80	20	1	2	3	5	N1	14.0																				0	0
8-21-80	20	1	9	3	5	N1	14.0																				0	0
8-22-80	20	1	3	2	5	N2	18.0																				0	0
8-22-80	20	1	3	1	5	N2	18.0																				0	0

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
8-22-80	20	1	2	3	5	N2	18.0	32																			32	0
8-22-80	20	1	9	3	5	N2	18.0	13																			13	0
8-22-80	20	1	3	2	5	D1	15.5																				0	0
8-22-80	20	1	3	1	5	D1	15.5																				0	0
8-22-80	20	1	2	3	5	D1	15.5																				0	0
8-22-80	20	1	9	3	5	D1	15.5																				0	0
8-22-80	20	1	3	2	5	D2	14.0																				0	0
8-22-80	20	1	3	1	5	D2	14.0																				0	0
8-22-80	20	1	2	3	5	D2	14.0																				0	43
8-22-80	20	1	9	3	5	D2	14.0																				0	0
8-28-80	21	1	3	2	5	D2	19.0																				0	0
8-28-80	21	1	3	1	5	D2	19.0																				0	0
8-28-80	21	1	2	3	5	D2	19.0																				0	0
8-28-80	21	1	9	3	5	D2	19.0																				0	0
8-28-80	21	1	3	2	5	N1	17.0																				0	0
8-28-80	21	1	3	1	5	N1	17.0																				0	0
8-28-80	21	1	2	3	5	N1	17.0																				0	0
8-28-80	21	1	9	3	5	N1	17.0																				0	0
8-29-80	21	1	3	2	5	N2	19.0																				0	0
8-29-80	21	1	3	1	5	N2	19.0																				0	0
8-29-80	21	1	2	3	5	N2	19.0																				0	0
8-29-80	21	1	9	3	5	N2	19.0																				0	0
8-29-80	21	1	3	2	5	D1	20.5																				0	0
8-29-80	21	1	3	1	5	D1	20.5																				0	0
8-29-80	21	1	2	3	5	D1	20.5																				0	0
8-29-80	21	1	9	3	5	D1	20.5																				0	0
9-08-80	22	1	2	3	5	N1	18.5																				0	0
9-08-80	22	1	3	1	5	N1	18.5																				0	0
9-08-80	22	1	3	2	5	N1	20.0																				0	0
9-08-80	22	3	9	3	5	N1	19.0																				0	0
9-09-80	22	1	2	3	5	N2	21.0																				0	0
9-09-80	22	1	3	1	5	N2	20.8	19																			19	0
9-09-80	22	1	3	2	5	N2	21.0	32																			32	0
9-09-80	22	1	9	3	5	N2	20.9																				0	0
9-09-80	22	1	2	3	5	D1	23.0																				0	0
9-09-80	22	1	3	1	5	D1	23.5																				0	0
9-09-80	22	1	3	2	5	D1	23.0																				0	0
9-09-80	22	1	9	3	5	D1	23.2																				0	0
9-09-80	22	1	2	3	5	D2	23.5																				0	0
9-09-80	22	1	3	1	5	D2	23.5																				0	0
9-09-80	22	1	3	2	5	D2	24.0																				0	0

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
9-09-80	22	1	9	3	5	D2	9.5																				0	0
9-23-80	23	1	3	1	5	N1	18.0	20																			20	0
9-23-80	23	1	3	2	5	N1	18.0	23																			23	0
9-23-80	23	1	2	3	5	N1	18.0	25																			25	0
9-23-80	23	1	9	3	5	N1	18.0																				0	0
9-24-80	23	1	3	1	5	N2	18.0																				0	0
9-24-80	23	1	3	2	5	N2	18.0																				0	0
9-24-80	23	1	2	3	5	N2	18.0																				0	0
9-24-80	23	1	9	3	5	N2	18.0																				0	0
9-24-80	23	1	3	1	5	D1	18.0																				0	0
9-24-80	23	1	3	2	5	D1	18.0																				0	0
9-24-80	23	1	2	3	5	D1	18.0																				0	0
9-24-80	23	1	9	3	5	D1	18.0																				0	0
9-23-80	23	1	3	1	5	D2	17.0																				0	0
9-23-80	23	1	3	2	5	D2	17.0																				0	0
9-23-80	23	1	2	3	5	D2	17.0																				0	0
9-23-80	23	1	9	3	5	D2	17.0																				0	0
10-13-80	24	1	3	2	5	N1	16.0																				0	0
10-13-80	24	3	3	1	5	N1	16.0																				0	0
10-13-80	24	1	2	3	5	N1	15.5																				0	0
10-13-80	24	1	9	3	5	N1	26.5																				0	0
10-14-80	24	1	3	2	5	N2	15.0																				0	0
10-14-80	24	1	3	1	5	N2	14.8																				0	0
10-14-80	24	1	2	3	5	N2	15.0																				0	0
10-14-80	24	1	9	3	5	N2	14.9																				0	0
10-14-80	24	1	3	2	5	D1	14.5																				0	0
10-14-80	24	1	3	1	5	D1	15.0																				0	0
10-14-80	24	3	2	3	5	D1	14.6																				0	0
10-14-80	24	1	9	3	5	D1	14.7																				0	0
10-14-80	24	1	3	2	5	D2	14.2																				0	0
10-14-80	24	1	3	1	5	D2	15.0																				0	0
10-14-80	24	1	2	3	5	D2	14.6																				0	0
10-14-80	24	1	9	3	5	D2	14.6																				0	0
10-29-80	25	3	3	2	5	D2	11.0																				0	0
10-29-80	25	3	3	1	5	D2	11.0																				0	0
10-29-80	25	1	2	3	5	D2	11.0																				0	0
10-29-80	25	1	9	3	5	D2	11.0																				0	0
10-29-80	25	3	3	2	5	N1	11.0																				0	0
10-29-80	25	3	3	1	5	N1	11.0																				0	0
10-29-80	25	1	2	3	5	N1	11.0																				0	28

Appendix 1. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
10-29-80	25	1	9	3	5	N1	11.0					14															14	0
10-29-80	25	1	3	2	5	N2	11.0																				0	17
10-29-80	25	1	3	1	5	N2	11.0																				0	0
10-29-80	25	1	2	3	5	N2	11.0																				0	0
10-29-80	25	1	9	3	5	N2	11.0																				0	0
10-29-80	25	1	3	2	5	D1	9.5																				0	0
10-29-80	25	1	3	1	5	D1	9.5																				0	0
10-29-80	25	1	2	3	5	D1	9.5																				0	0
10-29-80	25	1	9	3	5	D1	9.5																				0	0
11-10-80	26	1	3	2	5	N1	10.2																				0	0
11-10-80	26	1	3	1	5	N1	10.0																				0	0
11-10-80	26	1	2	3	5	N1	10.5																				0	0
11-10-80	26	1	9	3	5	N1	10.2																				0	0
11-11-80	26	1	3	2	5	N2	9.8																				0	0
11-11-80	26	1	3	1	5	N2	9.8																				0	0
11-11-80	26	1	2	3	5	N2	10.3																				0	0
11-11-80	26	1	9	3	5	N2	10.0																				0	0
11-11-80	26	1	3	2	5	D1	9.0																				0	0
11-11-80	26	1	3	1	5	D1	9.4																				0	0
11-11-80	26	1	2	3	5	D1	9.5																				0	0
11-11-80	26	1	9	3	5	D1	9.3																				0	0
11-11-80	26	1	3	2	5	D2	9.2																				0	0
11-11-80	26	1	3	1	5	D2	9.3																				0	0
11-11-80	26	1	2	3	5	D2	9.8																				0	0
11-11-80	26	1	9	3	5	D2	5.2																				0	0
11-24-80	27	1	3	2	5	N1	7.0																				0	0
11-24-80	27	1	3	1	5	N1	7.0																				0	0
11-24-80	27	1	2	3	5	N1	7.0																				0	0
11-24-80	27	1	9	3	5	N1	7.0																				0	0
11-25-80	27	1	3	2	5	N2	7.0																				0	0
11-25-80	27	1	3	1	5	N2	7.0																				0	0
11-25-80	27	1	2	3	5	N2	7.0																				0	0
11-25-80	27	1	9	3	5	N2	7.0																				0	0
11-25-80	27	1	3	2	5	D1	7.0																				0	0
11-25-80	27	1	3	1	5	D1	7.0																				0	0
11-25-80	27	1	2	3	5	D1	7.0																				0	0
11-25-80	27	1	9	3	5	D1	7.0																				0	0
11-25-80	27	1	3	2	5	D2	7.0																				0	0
11-25-80	27	1	3	1	5	D2	7.0																				0	0
11-25-80	27	1	2	3	5	D2	7.0																				0	0
11-25-80	27	1	9	3	5	D2	7.0																				0	0

Appendix 1. Continued.

Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
12-08-80	28	1	3	2	5	N1	6.8																				0	0
12-08-80	28	1	3	1	5	N1	7.0																				0	0
12-08-80	28	1	2	3	5	N1	6.3																				0	0
12-08-80	28	1	9	3	5	N1	6.7																				0	0
12-09-80	28	1	3	2	5	N2	7.8																				0	0
12-09-80	28	1	3	1	5	N2	7.8																				0	0
12-09-80	28	1	2	3	5	N2	7.0																				0	0
12-09-80	28	1	9	3	5	N2	7.8																				0	0
12-09-80	28	1	3	2	5	D1	7.0																				0	0
12-09-80	28	1	3	1	5	D1	6.5																				0	0
12-09-80	28	1	2	3	5	D1	6.9																				0	0
12-09-80	28	1	9	3	5	D1	6.8																				0	0
12-09-80	28	1	3	2	5	D2	5.5																				0	0
12-09-80	28	1	3	1	5	D2	5.7																				0	0
12-09-80	28	1	2	3	5	D2	5.3																				0	0
12-09-80	28	1	9	3	5	D2	5.5																				0	0
12-17-80	29	1	3	2	5	D2	10.5																				0	0
12-17-80	29	1	3	1	5	D2	7.5																				0	0
12-17-80	29	1	2	3	5	D2	7.5																				0	0
12-17-80	29	1	9	3	5	D2	8.5																				0	0
12-17-80	29	1	3	2	5	N1	4.0																				0	0
12-17-80	29	1	3	1	5	N1	4.5																				0	0
12-17-80	29	1	2	3	5	N1	4.5																				0	0
12-17-80	29	1	9	3	5	N1	4.3																				0	0
12-18-80	29	1	3	2	5	N2	4.0																				0	0
12-18-80	29	1	3	1	5	N2	4.5																				0	0
12-18-80	29	1	2	3	5	N2	4.5																				0	0
12-18-80	29	1	9	3	5	N2	4.3																				0	0
12-18-80	29	1	3	2	5	D1	5.0																				0	0
12-18-80	29	1	3	1	5	D1	6.0																				0	0
12-18-80	29	1	2	3	5	D1	6.0																				0	0
12-18-80	29	1	9	3	5	D1	5.7																				0	0

Appendix 2. Densities (no./1000 m³) for fish eggs and larvae entrained at the D.C. Cook Plant, southeastern Lake Michigan, 1981. Sample parameter codes are: Mpd (month period): consecutive number of the sample period during the annual sample program. Ser (series): (1) standard series, (2) supplemental sample, (3) problems-sample not used in calculations. Grt (grate): location of forebay grate, see Fig. 3 for reference. N/S (north/south): further designation of sampling location at each grate, (1) north, (2) south, (3) no designation, see Fig. 3 fo. reference. Dpt (depth): depth (m) of sampling in the forebay. Dl (diel): (N1) midnight to dawn, (D1) dawn to noon, (D2) noon to dusk, (N2) dusk to midnight, (LD and LN) long day or long night, samples extending beyond normal diel schedule, (OD and ON) other day or other night, sampling was performed at irregular intervals. Temp: temperature (C) of intake water when the sample was collected. Refer to Table 12 for species designation. Blank entries indicate zero densities.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
1-12-81	1	1	3	2	5	N1	0.0																				0	0
1-12-81	1	1	3	1	5	N1	0.2																				0	0
1-12-81	1	1	2	3	5	N1	0.0																				0	0
1-12-81	1	1	9	3	5	N1	0.0																				0	0
1-13-81	1	1	3	2	5	N2	0.5																				0	0
1-13-81	1	1	3	1	5	N2	2.3																				0	0
1-13-81	1	1	2	3	5	N2	2.4																				0	0
1-13-81	1	1	9	3	5	N2	1.7																				0	18
1-13-81	1	1	3	2	5	D1	4.2																				0	0
1-13-81	1	1	3	1	5	D1	2.3																				0	0
1-13-81	1	1	2	3	5	D1	4.0																				0	0
1-13-81	1	1	9	3	5	D1	3.5																				0	0
1-13-81	1	1	3	2	5	D2	3.3																				0	0
1-13-81	1	1	3	1	5	D2	4.7																				0	0
1-13-81	1	1	2	3	5	D2	3.1																				0	0
1-13-81	1	1	9	3	5	D2	3.7																				0	0
1-27-81	2	1	3	2	5	N1	3.5																				0	0
1-27-81	2	1	3	1	5	N1	3.5																				0	0
1-27-81	2	1	2	3	5	N1	3.5																				0	29
1-27-81	2	1	9	3	5	N1	3.5																				0	0
1-28-81	2	1	3	2	5	D2	3.5																				0	18
1-28-81	2	1	3	1	5	D2	3.5																				0	0
1-28-81	2	1	2	3	5	D2	3.5																				0	21
1-28-81	2	1	9	3	5	D2	3.5																				0	96
1-28-81	2	1	3	2	5	N2	3.5																				0	42
1-28-81	2	1	3	1	5	N2	3.5																				0	72
1-28-81	2	1	2	3	5	N2	3.5																				0	239
1-28-81	2	1	9	3	5	N2	3.5																				0	169
1-28-81	2	1	3	2	5	D1	3.5																				0	0
1-28-81	2	1	3	2	5	D1	3.5																				0	0
1-28-81	2	1	2	3	5	D1	3.5																				0	32
1-28-81	2	1	9	3	5	D1	3.5																				0	341
2-09-81	3	1	3	2	5	N1	4.0																				0	0

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
2-09-81	3	1	3	1	5	N1	2.5																				0	0
2-09-81	3	1	2	3	5	N1	6.0																				0	0
2-09-81	3	1	9	3	5	N1	4.2																				0	20
2-10-81	3	1	3	2	5	D2	4.0																				0	0
2-10-81	3	1	3	1	5	D2	2.6																				0	0
2-10-81	3	1	2	3	5	D2	4.0																				0	0
2-10-81	3	1	9	3	5	D2	3.5																				0	0
2-10-81	3	1	3	2	5	N2	5.0																				0	0
2-10-81	3	1	3	1	5	N2	4.9																				0	19
2-10-81	3	1	2	3	5	N2	4.5																				0	0
2-10-81	3	1	9	3	5	N2	4.8																				0	24
2-10-81	3	1	3	2	5	D1	4.0																				0	0
2-10-81	3	1	3	1	5	D1	3.5																				0	0
2-10-81	3	1	2	3	5	D1	4.8																				0	0
2-10-81	3	1	9	3	5	D1	4.1																				0	0
2-25-81	4	1	3	2	5	D2	6.0																				0	0
2-25-81	4	1	3	1	5	D2	6.0																				0	0
2-25-81	4	1	2	3	5	D2	6.0																				0	0
2-25-81	4	1	9	3	5	D2	6.0																				0	0
2-25-81	4	1	3	2	5	N1	4.0																				0	0
2-25-81	4	1	3	1	5	N1	4.0																				0	0
2-25-81	4	1	2	3	5	N1	4.0																				0	0
2-25-81	4	1	9	3	5	N1	4.0																				0	0
2-26-81	4	1	3	2	5	N2	3.5																				0	0
2-26-81	4	1	3	1	5	N2	3.5																				0	0
2-26-81	4	1	2	3	5	N2	3.5																				0	0
2-26-81	4	1	9	3	5	N2	3.5																				0	0
2-26-81	4	1	3	2	5	D1	4.0																				0	0
2-26-81	4	1	3	1	5	D1	4.0																				0	0
2-26-81	4	1	2	3	5	D1	4.0																				0	0
2-26-81	4	1	9	3	5	D1	4.0																				0	0
3-16-81	5	1	3	2	5	N1	4.5																				0	0
3-16-81	5	1	3	1	5	N1	3.9																				0	53
3-16-81	5	1	2	3	5	N1	3.5																				0	0
3-16-81	5	1	9	3	5	N1	3.9																				0	0
3-17-81	5	1	3	2	5	D2	5.5																				0	67
3-17-81	5	1	3	1	5	D2	4.5																				0	0
3-17-81	5	1	2	3	5	D2	4.8																				0	39
3-17-81	5	1	9	3	5	D2	4.7																				0	0
3-17-81	5	1	3	2	5	N2	4.0																				0	76
3-17-81	5	1	3	1	5	N2	3.4																				0	0

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
3-17-81	5	1	2	3	5	N2	4.0																				0	0
3-17-81	5	1	9	3	5	N2	3.8																				0	0
3-17-81	5	1	3	1	5	D1	4.0																				0	0
3-17-81	5	1	2	3	5	D1	4.5																				0	0
3-17-81	5	1	9	3	5	D1	4.2																				0	0
3-25-81	6	1	3	2	5	N1	10.1																				0	0
3-25-81	6	1	3	1	5	N1	10.1																				0	0
3-25-81	6	1	2	3	5	N1	10.1																				0	0
3-25-81	6	1	9	3	5	N1	10.1																				0	0
3-26-81	6	1	3	2	5	D2	4.5																				0	0
3-26-81	6	1	3	1	5	D2	4.5																				0	0
3-26-81	6	1	2	3	5	D2	4.5																				0	0
3-26-81	6	1	9	3	5	D2	4.5																				0	0
3-26-81	6	1	3	2	5	N2	4.5																				0	0
3-26-81	6	1	3	1	5	N2	4.5																				0	0
3-26-81	6	1	2	3	5	N2	4.5																				0	0
3-26-81	6	1	9	3	5	N2	4.5																				0	0
3-26-81	6	1	3	2	5	D1	4.0																				0	0
3-26-81	6	1	3	1	5	D1	4.0																				0	24
3-26-81	6	1	2	3	5	D1	4.0																				0	0
3-26-81	6	1	9	3	5	D1	4.0																				0	0
4-06-81	7	1	3	2	5	N1	12.0																				0	0
4-06-81	7	1	3	1	5	N1	8.0																				0	0
4-06-81	7	1	2	3	5	N1	10.0																				0	0
4-06-81	7	1	9	3	5	N1	10.0																				0	0
4-06-81	7	1	3	2	5	N2	7.8																				0	0
4-07-81	7	1	3	1	5	N2	7.7																				0	0
4-07-81	7	1	2	3	5	N2	7.5																				0	0
4-07-81	7	1	9	3	5	N2	7.7																				0	0
4-07-81	7	1	3	2	5	D1	8.0																				0	0
4-07-81	7	1	3	1	5	D1	8.0																				0	0
4-07-81	7	1	2	3	5	D1	7.5																				0	0
4-07-81	7	1	9	3	5	D1	7.8																				0	0
4-07-81	7	1	3	2	5	D2	8.0																				0	0
4-07-81	7	1	3	1	5	D2	8.0																				0	0
4-07-81	7	1	2	3	5	D2	7.8																				0	0
4-07-81	7	1	9	3	5	D2	7.9																				0	0
4-21-81	8	1	3	2	5	N1	8.0																				0	27
4-21-81	8	1	3	1	5	N1	8.0																				0	0
4-21-81	8	1	2	3	5	N1	8.0																				0	0

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
4-21-81	8	1	9	3	5	N1	8.0																				0	27
4-21-81	8	1	3	2	5	D2	8.0																				0	18
4-21-81	8	1	3	1	5	D2	8.0																				0	18
4-21-81	8	1	2	3	5	D2	8.0																				0	0
4-21-81	8	1	9	3	5	D2	8.0																				0	0
4-22-81	8	1	3	2	5	N2	8.0			21																	21	0
4-22-81	8	1	3	1	5	N2	8.0																				0	0
4-22-81	8	1	2	3	5	N2	8.0																				0	0
4-22-81	8	1	9	3	5	N2	8.0																				0	0
4-22-81	8	1	3	2	5	D1	8.0																				0	40
4-22-81	8	1	3	1	5	D1	8.0																				0	22
4-22-81	8	1	2	3	5	D1	8.0																				0	19
4-22-81	8	1	9	3	5	D1	8.0																				0	117
5-11-81	9	1	3	2	5	N1	9.5																				0	0
5-11-81	9	1	3	1	5	N1	9.0													52							52	0
5-11-81	9	1	2	3	5	N1	13.0																				0	113
5-11-81	9	1	9	3	5	N1	10.5																				0	0
5-11-81	9	1	3	2	5	N2	9.7																				0	346
5-11-81	9	1	3	1	5	N2	9.2			66				22								22					110	315
5-11-81	9	1	2	3	5	N2	10.0		17	17																	34	362
5-11-81	9	1	9	3	5	N2	9.9			11	11			11								22					55	255
5-12-81	9	1	3	2	5	D1	10.0			92										46							138	93
5-12-81	9	1	3	1	5	D1	9.2		21					21						21							63	21
5-12-81	9	1	2	3	5	D1	10.1		19											19							38	117
5-12-81	9	1	9	3	5	D1	4.8		15	15	30																60	46
5-12-81	9	1	3	2	5	D2	9.5			33				11													44	79
5-12-81	9	1	3	1	5	D2	9.0			33												11	11				55	240
5-12-81	9	1	2	3	5	D2	9.5		11					11													22	402
5-12-81	9	1	9	3	5	D2	9.3																				0	209
5-26-81	10	1	3	2	5	N1	16.0								24												24	312
5-26-81	10	1	2	3	5	N1	16.0																				0	692
5-26-81	10	1	9	3	5	N1	16.0																				0	332
5-27-81	10	1	3	2	5	N2	16.0			18																	18	3376
5-27-81	10	1	3	1	5	N2	16.0								90												90	3634
5-27-81	10	1	2	3	5	N2	16.0																				0	4969
5-27-81	10	1	9	3	5	N2	16.0							16													16	1184
5-27-81	10	1	3	2	5	D1	15.0								14												14	344
5-27-81	10	1	3	2	5	D1	15.0																				0	918
5-27-81	10	1	2	3	5	D1	15.0																				0	218
5-27-81	10	1	9	3	5	D1	15.0																				0	133
5-27-81	10	1	3	2	5	D2	16.0								11												11	189

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
5-27-81	10	1	3	1	5	D2	16.0															21					21	344
5-27-81	10	1	2	3	5	D2	16.0																				0	92
5-27-81	10	1	9	3	5	D2	16.0			10																	10	147
6-02-81	11	1	3	2	5	D2	15.0																				0	31
6-02-81	11	1	3	1	5	D2	15.0									16											16	65
6-02-81	11	1	2	3	5	D2	15.0	14																			14	87
6-02-81	11	2	8	3	5	D2	17.0			28																	28	144
6-02-81	11	1	3	2	5	N1	17.0																				0	50
6-02-81	11	1	3	1	5	N1	17.0																				0	76
6-02-81	11	1	2	3	5	N1	17.0			36					36												72	72
6-02-81	11	2	8	3	5	N1	17.0			29				29													58	118
6-03-81	11	1	3	2	5	N2	17.0			18																	18	222
6-03-81	11	1	3	1	5	N2	17.0																				0	309
6-03-81	11	1	2	3	5	N2	17.0																				0	255
6-03-81	11	2	8	3	5	N2	17.0								23												23	307
6-03-81	11	1	3	2	5	D1	17.0							13													13	151
6-03-81	11	1	3	1	5	D1	17.0																				0	105
6-03-81	11	1	2	3	5	D1	17.0																				0	38
6-03-81	11	2	8	3	5	D1	17.0																				0	327
6-08-81	12	1	3	2	5	N1	18.0	33							33												66	401
6-08-81	12	1	3	1	5	N1	18.0	181	60						60												301	1153
6-08-81	12	1	2	3	5	N1	17.5	66							33												99	67
6-08-81	12	2	8	3	5	N1	17.8	230			46				46												322	462
6-08-81	12	1	3	2	5	N2	17.5	15						15													30	4658
6-08-81	12	1	3	1	5	N2	17.9																				0	5693
6-08-81	12	1	2	3	5	N2	17.0																				0	1501
6-08-81	12	2	8	3	5	N2	17.5	40						20								20					80	8104
6-09-81	12	1	3	2	5	D1	17.5	64																			64	482
6-09-81	12	1	3	1	5	D1	17.5	53																			53	1043
6-09-81	12	1	2	3	5	D1	17.0	32																			32	691
6-09-81	12	2	8	3	5	D1	17.3	63																			63	851
6-09-81	12	1	3	2	5	D2	18.0	31			10			52													93	275
6-09-81	12	1	3	1	5	D2	17.9	80																			80	327
6-09-81	12	1	2	3	5	D2	18.0	31																			31	87
6-09-81	12	2	8	3	5	D2	18.0	26						39													65	249
6-12-81	13	1	3	2	5	N1	21.0	309	28					84													421	2092
6-12-81	13	1	3	1	5	N1	21.0	602						35	35												672	3972
6-12-81	13	1	2	3	5	N1	21.0	682	65							32											779	2998
6-12-81	13	2	8	3	5	N1	21.0	784					62			62											908	5470
6-12-81	13	1	3	2	5	N2	20.0	122																			122	16614

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
6-12-81	13	2	8	3	5	N2	20.0	190						38		19											247	38868
6-13-81	13	1	3	1	5	N2	20.0	211	46					23													280	19470
6-13-81	13	1	2	3	5	N2	20.0	81			20																101	16447
6-13-81	13	1	3	2	5	D1	20.0	153	15																		168	1794
6-13-81	13	1	3	1	5	D1	20.0	287						20													307	4732
6-13-81	13	1	2	3	5	D1	20.0	126																			126	2602
6-13-81	13	2	8	3	5	D1	20.0	281																			281	5103
6-13-81	13	1	3	2	5	D2	19.0	57						33													90	818
6-13-81	13	1	3	1	5	D2	19.0	407	18					55													480	2444
6-13-81	13	1	2	3	5	D2	19.0	14	14					42													70	1531
6-13-81	13	2	8	3	5	D2	19.0	100						37													137	1980
6-15-81	14	1	3	2	5	N1	23.0	2166	120	60																	2346	4817
6-15-81	14	1	3	1	5	N1	23.0	2007						37													2044	9399
6-15-81	14	1	2	3	5	N1	23.0	1379		32				96													1507	7355
6-15-81	14	2	8	3	5	N1	23.0	1339	118	58	59			118													1692	4444
6-16-81	14	1	3	2	5	N2	21.0	1179	380		31			221													1811	1820
6-16-81	14	1	3	1	5	N2	21.0	1234	190					163													1587	2609
6-16-81	14	1	2	3	5	N2	21.0	563	382	22	112			201													1280	1129
6-16-81	14	2	8	3	5	N2	21.0	1022	471	96	19			549		19											2176	2027
6-16-81	14	1	3	2	5	D1	20.0	1926	38		98			118													2180	974
6-16-81	14	1	3	1	5	D1	20.0	2005	122					196													2323	1090
6-16-81	14	1	2	3	5	D1	20.0	1096	54		18			216													1384	421
6-16-81	14	2	8	3	5	D1	20.0	1794	15		139			152								15					2115	1080
6-16-81	14	1	3	2	5	D2	20.0	1498	14		140	42		310													2004	2475
6-16-81	14	1	2	3	5	D2	20.0	1141	84	14	56		14	273													1582	2199
6-16-81	14	2	8	3	5	D2	20.0	1207	24		206		12	315													1764	2859
6-18-81	15	1	2	3	5	N2	20.0	142		60				162													364	6398
6-19-81	15	1	3	2	5	N1	17.0	56						28													84	855
6-19-81	15	1	3	1	5	N1	17.0	76						154													230	935
6-19-81	15	1	2	3	5	N1	17.0		205					170													375	892
6-19-81	15	2	8	3	5	N1	17.0				24			193													217	1115
6-19-81	15	1	3	2	5	N2	20.0		19					77													96	8387
6-19-81	15	1	3	1	5	N2	20.0	175			117			29													321	11585
6-19-81	15	2	8	3	5	N2	20.0							80													80	8925
6-19-81	15	1	3	2	5	D1	19.0	94			61			45													200	1434
6-19-81	15	1	3	1	5	D1	19.0	21			21			21													63	1585
6-19-81	15	1	2	3	5	D1	19.0				17																17	989
6-19-81	15	2	8	3	5	D1	19.0							14													14	1019
6-19-81	15	1	3	2	5	D2	18.0		12		12			12													36	491
6-19-81	15	1	3	1	5	D2	18.0	51	17																		68	932
6-19-81	15	1	2	3	5	D2	18.0	13	13					13													39	487

Appendix 2. Continued.

Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
6-19-81	15	2	8	3	5	D2	18.0							12													12	111
6-22-81	16	1	3	2	5	N1	18.0	159	26																		185	241
6-22-81	16	1	3	1	5	N1	18.0		33																		33	203
6-22-81	16	1	2	3	5	N1	18.0	210						60													270	271
6-22-81	16	2	8	3	5	N1	18.0	184		23				92													299	345
6-23-81	16	1	3	2	5	N2	17.0	231	42	21		21		42													357	1703
6-23-81	16	1	3	1	5	N2	17.0	30			30																60	3003
6-23-81	16	1	2	3	5	N2	17.0	104	52																		156	3902
6-23-81	16	2	8	3	5	N2	17.0	15	15	30				30													90	817
6-23-81	16	1	3	2	5	D1	15.0	84						14													98	872
6-23-81	16	1	3	1	5	D1	15.0	82	41					20													143	1615
6-23-81	16	1	2	3	5	D1	15.0	34	17																		51	720
6-23-81	16	2	8	3	5	D1	15.0	14						14													28	863
6-23-81	16	1	3	2	5	D2	16.0																				0	136
6-23-81	16	1	3	1	5	D2	16.0	57	38		19			57													171	285
6-23-81	16	1	2	3	5	D2	16.0	15																			15	268
6-23-81	16	2	8	3	5	D2	16.0	46																			46	222
6-24-81	17	1	3	2	5	N1	18.0	218																			218	912
6-24-81	17	1	3	1	5	N1	18.0	148	37					148													333	1945
6-24-81	17	1	2	3	5	N1	18.0																				0	2493
6-24-81	17	2	8	3	5	N1	18.0	99		33				66													198	2487
6-24-81	17	1	2	3	5	N2	18.0	106		21				42													169	6575
6-25-81	17	1	3	2	5	N2	18.0	36																			36	6086
6-25-81	17	1	3	1	5	N2	18.0	27			27																54	6331
6-25-81	17	2	8	3	5	N2	18.0	93						47													140	15249
6-25-81	17	1	3	2	5	D1	19.0	28	14																		42	861
6-25-81	17	1	3	1	5	D1	19.0	168						21													189	1059
6-25-81	17	1	2	3	5	D1	19.0	137	17																		154	1069
6-25-81	17	2	8	3	5	D1	19.0	48						32													80	1548
6-25-81	17	1	3	2	5	D2	20.0	36						24													60	571
6-25-81	17	1	3	1	5	D2	20.0	140						20													160	484
6-25-81	17	1	2	3	5	D2	20.0	112																			112	291
6-25-81	17	2	8	3	5	D2	20.0	199						15													214	404
6-30-81	18	1	3	2	5	D2	20.0	1681						22													1703	1490
6-30-81	18	1	3	1	5	D2	20.0	2359	16					65													2440	1902
6-30-81	18	1	2	3	5	D2	20.0	1104						131													1235	1346
6-30-81	18	2	8	3	5	D2	20.0	1413				13		13													1439	3396
6-30-81	18	1	3	2	5	N1	18.5	1211																			1211	2731
6-30-81	18	1	3	1	5	N1	18.5	3971																			3971	3973
6-30-81	18	1	2	3	5	N1	18.5	1727																			1727	6916

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
6-30-81	18	2	8	3	5	N1	18.5	2299						33													2332	9502
7-01-81	18	1	3	2	5	N2	18.0	878	20		40		20	60													1018	14266
7-01-81	18	1	3	1	5	N2	18.0	1346	28				28														1402	10607
7-01-81	18	1	2	3	5	N2	18.0	592						178													770	19134
7-01-81	18	2	8	3	5	N2	18.0	955	22		44			66													1087	24517
7-01-81	18	1	3	2	5	D1	15.0	158																			158	1697
7-01-81	18	1	3	1	5	D1	15.0	700																			700	1852
7-01-81	18	1	2	3	5	D1	15.0	105						87													192	1045
7-01-81	18	2	8	3	5	D1	15.0	276																			276	2829
7-02-81	19	1	3	2	5	D2	16.0	28	14																		42	248
7-02-81	19	1	3	1	5	D2	16.0	295						85													380	540
7-02-81	19	1	2	3	5	D2	16.0	28																			28	100
7-02-81	19	2	8	3	5	D2	16.0	14																			14	354
7-02-81	19	1	3	2	5	N1	15.0	350						140													490	245
7-02-81	19	1	3	1	5	N1	15.0	356																			356	557
7-02-81	19	1	2	3	5	N1	15.0	292						36													328	257
7-02-81	19	2	8	3	5	N1	15.0	337																			337	1411
7-03-81	19	1	3	2	5	N2	17.0	225																			225	1012
7-03-81	19	1	3	1	5	N2	17.0	999						540													1539	594
7-03-81	19	1	2	3	5	N2	17.0	23						46													69	603
7-03-81	19	2	8	3	5	N2	17.0	222																			222	4138
7-03-81	19	1	3	2	5	D1	15.0	264																			264	861
7-03-81	19	1	3	1	5	D1	15.0	240																			240	665
7-03-81	19	1	2	3	5	D1	15.0	52						17													69	279
7-03-81	19	2	8	3	5	D1	15.0	203																			203	1264
7-13-81	20	1	3	2	5	N1	24.0	448						37													485	7672
7-13-81	20	1	3	1	5	N1	23.7	375						150													525	3463
7-13-81	20	1	2	3	5	N1	23.5	249						124													373	6475
7-13-81	20	2	8	3	5	N1	23.7							166													166	8109
7-13-81	20	1	3	2	5	N2	23.8	15	15					15													45	8997
7-13-81	20	1	3	1	5	N2	23.7	112																			112	50012
7-13-81	20	1	2	3	5	N2	23.5	51						17													68	40958
7-13-81	20	2	8	3	5	N2	23.7																				0	94211
7-14-81	20	1	3	2	5	D1	23.5	16																			16	3320
7-14-81	20	1	3	1	5	D1	23.2	26																			26	8170
7-14-81	20	1	2	3	5	D1	23.3																				0	5513
7-14-81	20	2	8	3	5	D1	23.3	55	18																		73	10784
7-14-81	20	1	3	2	5	D2	23.0																				0	930
7-14-81	20	1	3	1	5	D2	23.2	32																			32	2432
7-14-81	20	1	2	3	5	D2	22.8																				0	2916
7-14-81	20	2	8	3	5	D2	23.0	30																			30	1428

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
7-16-81	21	1	3	2	5	N1	9.0					29															29	59
7-16-81	21	1	3	1	5	N1	9.0																				0	117
7-16-81	21	1	2	3	5	N1	9.0																				0	83
7-16-81	21	2	8	3	5	N1	9.0																				0	104
7-16-81	21	1	3	2	5	D2	16.0	36						24													60	389
7-16-81	21	1	3	1	5	D2	16.0	30																			30	492
7-16-81	21	1	2	3	5	D2	16.0	30																			30	110
7-16-81	21	2	8	3	5	D2	16.0																				0	210
7-17-81	21	1	3	2	5	N2	9.0																				0	157
7-17-81	21	1	3	1	5	N2	9.0																				0	307
7-17-81	21	1	2	3	5	N2	9.0																				0	172
7-17-81	21	2	8	3	5	N2	9.0																				0	215
7-17-81	21	1	3	2	5	D1	11.0																				0	96
7-17-81	21	1	3	1	5	D1	11.0	42																			42	214
7-17-81	21	1	2	3	5	D1	11.0	18																			18	54
7-17-81	21	2	8	3	5	D1	11.0	14	14																		28	115
7-20-81	22	1	3	2	5	N1	16.0							28													28	510
7-20-81	22	1	3	1	5	N1	16.0							38													38	504
7-20-81	22	1	2	3	5	N1	16.0							91													91	929
7-20-81	22	2	8	3	5	N1	16.0																				0	928
7-20-81	22	1	3	2	5	D2	14.0	12																			12	63
7-20-81	22	1	3	1	5	D2	14.0	97																			97	49
7-20-81	22	1	2	3	5	D2	14.0	28																			28	72
7-20-81	22	2	8	3	5	D2	14.0																				0	32
7-21-81	22	1	3	2	5	N2	20.0	46																			46	1423
7-21-81	22	1	3	1	5	N2	20.0	96						32													128	839
7-21-81	22	1	2	3	5	N2	20.0	104	26																		130	884
7-21-81	22	2	8	3	5	N2	20.0	122			20			20													162	1734
7-21-81	22	1	3	2	5	D1	18.0	275																			275	4661
7-21-81	22	1	2	3	5	D1	18.0	119																			119	1302
7-21-81	22	2	8	3	5	D1	18.0	112						37													149	1697
7-22-81	23	1	3	2	5	N1	15.0	93	62					31													186	1516
7-22-81	23	1	3	1	5	N1	15.0							40													40	1361
7-22-81	23	1	2	3	5	N1	15.0		33																		33	849
7-22-81	23	2	8	3	5	N1	15.0	148																			148	1538
7-22-81	23	1	3	2	5	D2	13.0																				0	1977
7-22-81	23	1	3	1	5	D2	13.0		15					15													30	2315
7-22-81	23	1	2	3	5	D2	13.0																				0	608
7-22-81	23	2	8	3	5	D2	13.0																				0	3609
7-23-81	23	1	3	2	5	N2	16.0	17																			17	791

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
7-23-81	23	1	3	1	5	N2	16.0		48					24													72	835
7-23-81	23	1	2	3	5	N2	16.0																				0	806
7-23-81	23	2	8	3	5	N2	16.0	63																			63	617
7-23-81	23	1	3	2	5	D1	18.0																				0	648
7-23-81	23	1	2	3	5	D1	18.0																				0	127
7-23-81	23	2	8	3	5	D1	18.0	17																			17	714
7-27-81	24	1	3	2	5	N1	18.0																				0	172
7-27-81	24	1	3	1	5	N1	18.0	66																			66	100
7-27-81	24	1	2	3	5	N1	18.0																				0	28
7-27-81	24	2	8	3	5	N1	18.0							33													33	33
7-28-81	24	1	3	2	5	N2	16.0	21																			21	1774
7-28-81	24	1	3	1	5	N2	16.0		28					28													56	1591
7-28-81	24	1	2	3	5	N2	16.0																				0	382
7-28-81	24	2	8	3	5	N2	16.0	69																			69	2247
7-28-81	24	1	3	2	5	D1	16.0	30																			30	322
7-28-81	24	1	3	1	5	D1	16.0	41						20													61	410
7-28-81	24	1	2	3	5	D1	16.0	17																			17	223
7-28-81	24	2	8	3	5	D1	16.0	16																			16	458
7-28-81	24	1	3	2	5	D2	17.0	12																			12	315
7-28-81	24	1	3	1	5	D2	17.0	15						15													30	717
7-28-81	24	1	2	3	5	D2	17.0																				0	692
7-28-81	24	2	8	3	5	D2	17.0	49																			49	466
7-30-81	25	1	3	2	5	N1	21.0	84																			84	0
7-30-81	25	1	3	1	5	N1	21.0																				0	150
7-30-81	25	1	2	3	5	N1	21.0																				0	0
7-30-81	25	2	8	3	5	N1	21.0		31																		31	221
7-30-81	25	1	3	2	5	D2	20.0	78																			78	69
7-30-81	25	1	3	1	5	D2	20.0	36																			36	18
7-30-81	25	1	2	3	5	D2	20.0	30																			30	30
7-30-81	25	2	8	3	5	D2	20.0	26																			26	0
7-31-81	25	1	3	2	5	N2	20.0																				0	235
7-31-81	25	1	3	1	5	N2	20.0	23																			23	185
7-31-81	25	1	2	3	5	N2	20.0																				0	123
7-31-81	25	2	8	3	5	N2	20.0	63	42																		105	381
7-31-81	25	1	3	2	5	D1	20.0																				0	81
7-31-81	25	1	3	1	5	D1	20.0																				0	88
7-31-81	25	1	2	3	5	D1	20.0																				0	0
7-31-81	25	2	8	3	5	D1	20.0																				0	44
8-02-81	26	1	3	2	5	N1	23.0	1202																			1202	0
8-02-81	26	1	3	1	5	N1	23.0	641																			641	0

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
8-02-81	26	1	2	3	5	N1	23.0	722																			722	0
8-02-81	26	1	9	3	5	N1	23.0	1416																			1416	74
8-03-81	26	1	3	2	5	N2	22.0	291																			291	0
8-03-81	26	1	3	1	5	N2	22.0	182																			182	0
8-03-81	26	1	2	3	5	N2	22.0	161																			161	23
8-03-81	26	1	9	3	5	N2	22.0	138																			138	69
8-03-81	26	1	3	2	5	D1	22.0	542						15													557	0
8-03-81	26	1	3	1	5	D1	22.0	299																			299	21
8-03-81	26	1	2	3	5	D1	22.0	553																			553	0
8-03-81	26	1	9	3	5	D1	22.0	466																			466	0
8-03-81	26	1	3	2	5	D2	22.0	126																			126	12
8-03-81	26	1	3	1	5	D2	22.0	144																			144	18
8-03-81	26	1	2	3	5	D2	22.0	75																			75	0
8-03-81	26	1	9	3	5	D2	22.0	249																			249	0
8-07-81	27	1	3	2	5	N1	23.0	405																			405	22
8-07-81	27	1	3	1	5	N1	23.0	312						93													405	94
8-07-81	27	1	2	3	5	N1	23.0	152																			152	128
8-07-81	27	1	9	3	5	N1	23.0	31						93													124	0
8-08-81	27	1	3	2	5	N2	23.0	139																			139	63
8-08-81	27	1	3	1	5	N2	23.0	191																			191	0
8-08-81	27	1	2	3	5	N2	23.0	171																			171	52
8-08-81	27	1	9	3	5	N2	23.0	183						20													203	188
8-08-81	27	1	3	2	5	D1	23.0	90						18													108	108
8-08-81	27	1	3	1	5	D1	23.0	122																			122	99
8-08-81	27	1	2	3	5	D1	23.0	38						19													57	177
8-08-81	27	1	9	3	5	D1	23.0	406																			406	458
8-08-81	27	1	3	2	5	D2	23.0	238	112																		350	252
8-08-81	27	1	3	1	5	D2	23.0	272	57																		329	471
8-08-81	27	1	2	3	5	D2	23.0	15	30					45													90	627
8-08-81	27	1	9	3	5	D2	23.0	120	121					68													309	388
8-10-81	28	1	3	2	5	N1	26.0	393	49					49													491	0
8-10-81	28	1	3	1	5	N1	24.7	428	107																		535	0
8-10-81	28	1	2	3	5	N1	24.8	66									66										132	0
8-10-81	28	2	8	3	5	N1	25.1	116																			116	58
8-10-81	28	1	3	2	5	N2	25.5	160	20																		180	101
8-10-81	28	1	3	1	5	N2	24.8	75	25																		100	0
8-10-81	28	1	2	3	5	N2	24.5	220	18					18													256	93
8-10-81	28	2	8	3	5	N2	24.9	126																			126	0
8-11-81	28	1	3	2	5	D1	24.0	123																			123	0
8-11-81	28	1	3	1	5	D1	24.0	93																			93	31
8-11-81	28	1	2	3	5	D1	23.9	21	21																		42	42

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Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
8-27-81	33	1	2	3	5	D1	23.0	22																			22	0
8-27-81	33	1	9	3	5	D1	23.0	42																			42	0
9-14-81	34	1	3	2	5	N1	22.2																				0	0
9-14-81	34	1	3	1	5	N1	22.4																				0	0
9-14-81	34	1	2	3	5	N1	22.6																				0	0
9-14-81	34	1	9	3	5	N1	22.4	28																			28	0
9-14-81	34	1	3	2	5	N2	22.3	26																			26	0
9-14-81	34	1	3	1	5	N2	22.2																				0	0
9-14-81	34	1	2	3	5	N2	22.3																				0	0
9-14-81	34	1	9	3	5	N2	22.3	12																			12	0
9-15-81	34	1	3	2	5	D1	23.7																				0	0
9-15-81	34	1	3	1	5	D1	23.4																				0	0
9-15-81	34	1	2	3	5	D1	23.1	21																			21	0
9-15-81	34	1	9	3	5	D1	23.4																				0	0
9-15-81	34	1	3	2	5	D2	23.6																				0	0
9-15-81	34	1	3	1	5	D2	23.5																				0	0
9-15-81	34	1	2	3	5	D2	23.5																				0	0
9-15-81	34	1	9	3	5	D2	23.5																				0	0
9-29-81	35	1	3	2	5	D2	17.5																				0	0
9-29-81	35	1	3	1	5	D2	17.0																				0	0
9-29-81	35	1	2	3	5	D2	17.0																				0	0
9-29-81	35	1	9	3	5	D2	17.0																				0	0
9-29-81	35	1	3	2	5	N1	17.0																				0	0
9-29-81	35	1	3	1	5	N1	17.0																				0	0
9-29-81	35	1	2	3	5	N1	17.0	16																			16	0
9-29-81	35	1	9	3	5	N1	17.0	15																			15	0
9-30-81	35	1	3	2	5	N2	17.0																				0	0
9-30-81	35	1	3	1	5	N2	17.0																				0	0
9-30-81	35	1	2	3	5	N2	17.0	40																			40	0
9-30-81	35	1	9	3	5	N2	17.0																				0	0
9-30-81	35	1	3	2	5	D1	17.0																				0	0
9-30-81	35	1	3	1	5	D1	17.0																				0	0
9-30-81	35	1	2	3	5	D1	17.0																				0	0
9-30-81	35	1	9	3	5	D1	17.0	18																			18	0
10-12-81	36	1	3	2	5	N1	15.0																				0	0
10-12-81	36	1	3	1	5	N1	14.6																				0	0
10-12-81	36	1	2	3	5	N1	15.0																				0	0
10-12-81	36	1	9	3	5	N1	14.9																				0	0
10-12-81	36	1	3	2	5	N2	14.7																				0	0
10-12-81	36	1	3	1	5	N2	15.0																				0	0

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
10-12-81	36	1	2	3	5	N2	15.0																				0	0
10-12-81	36	1	9	3	5	N2	15.0																				0	0
10-13-81	36	1	3	2	5	D1	14.7																				0	0
10-13-81	36	1	3	1	5	D1	14.4																				0	0
10-13-81	36	1	2	3	5	D1	14.5																				0	0
10-13-81	36	1	9	3	5	D1	14.5																				0	0
10-13-81	36	1	3	2	5	D2	14.6																				0	0
10-13-81	36	1	3	1	5	D2	14.3																				0	0
10-13-81	36	1	2	3	5	D2	14.6																				0	0
10-13-81	36	1	9	3	5	D2	14.5																				0	0
10-22-81	37	1	3	2	5	N1	10.5																				0	0
10-22-81	37	1	3	1	5	N1	10.5																				0	0
10-22-81	37	1	2	3	5	N1	10.5																				0	0
10-22-81	37	1	9	3	5	N1	10.5																				0	0
10-22-81	37	1	3	2	5	D2	10.5																				0	0
10-22-81	37	1	3	1	5	D2	10.5																				0	0
10-22-81	37	1	2	3	5	D2	10.5																				0	0
10-22-81	37	1	9	3	5	D2	10.5																				0	0
10-23-81	37	1	3	2	5	N2	11.0																				0	0
10-23-81	37	1	3	1	5	N2	11.0																				0	0
10-23-81	37	1	2	3	5	N2	11.0																				0	0
10-23-81	37	1	9	3	5	N2	11.0																				0	0
10-23-81	37	1	3	2	5	D1	12.0																				0	0
10-23-81	37	1	3	1	5	D1	12.0																				0	0
10-23-81	37	1	2	3	5	D1	12.0																				0	0
10-23-81	37	1	9	3	5	D1	12.0																				0	0
11-09-81	38	1	3	2	5	N1	11.0																				0	0
11-09-81	38	1	3	1	5	N1	10.2																				0	0
11-09-81	38	1	2	3	5	N1	10.5																				0	0
11-09-81	38	2	8	3	5	N1	10.5																				0	0
11-09-81	38	1	3	2	5	N2	11.5																				0	0
11-09-81	38	1	3	1	5	N2	10.3																				0	0
11-09-81	38	1	2	3	5	N2	10.5																				0	0
11-09-81	38	2	8	3	5	N2	10.8																				0	0
11-10-81	38	1	3	2	5	D1	11.2																				0	0
11-10-81	38	1	3	1	5	D1	10.7																				0	0
11-10-81	38	1	2	3	5	D1	11.0																				0	0
11-10-81	38	2	8	3	5	D1	10.9																				0	0
11-10-81	38	1	3	2	5	D2	11.1																				0	0
11-10-81	38	1	3	1	5	D2	10.8																				0	0
11-10-81	38	1	2	3	5	D2	11.4																				0	0

Appendix 2. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
11-10-81	38	2	8	3	5	D2	19.7																				0	0
11-23-81	39	1	3	2	5	D2	9.0																				0	0
11-23-81	39	1	3	1	5	D2	9.0																				0	0
11-23-81	39	1	2	3	5	D2	8.5																				0	0
11-23-81	39	1	9	3	5	D2	8.5																				0	0
11-23-81	39	1	3	2	5	N1	8.5																				0	0
11-23-81	39	1	3	1	5	N1	8.5																				0	19
11-23-81	39	1	2	3	5	N1	8.5																				0	0
11-23-81	39	1	9	3	5	N1	8.5																				0	0
11-24-81	39	1	3	2	5	N2	8.5																				0	0
11-24-81	39	1	3	1	5	N2	8.5																				0	0
11-24-81	39	1	2	3	5	N2	8.5																				0	0
11-24-81	39	1	9	3	5	N2	8.5																				0	0
11-24-81	39	1	3	2	5	D1	7.5																				0	0
11-24-81	39	1	3	1	5	D1	8.0																				0	0
11-24-81	39	1	2	3	5	D1	7.5																				0	0
11-24-81	39	1	9	3	5	D1	7.7																				0	0
12-07-81	40	1	3	2	5	N1	9.0																				0	0
12-07-81	40	1	3	1	5	N1	8.5																				0	0
12-07-81	40	1	2	3	5	N1	8.9																				0	0
12-07-81	40	2	8	3	5	N1	8.8																				0	0
12-08-81	40	1	3	2	5	D2	5.3																				0	0
12-08-81	40	1	3	1	5	D2	5.3																				0	0
12-08-81	40	1	2	3	5	D2	5.3																				0	0
12-08-81	40	2	8	3	5	D2	5.3																				0	0
12-08-81	40	1	3	2	5	N2	7.2																				0	0
12-08-81	40	1	3	1	5	N2	7.3																				0	0
12-08-81	40	1	2	3	5	N2	7.2																				0	0
12-08-81	40	2	8	3	5	N2	7.2																				0	0
12-08-81	40	1	3	2	5	D1	5.8																				0	0
12-08-81	40	1	2	3	5	D1	5.8																				0	0
12-08-81	40	2	8	3	5	D1	5.8																				0	0
12-15-81	41	1	3	2	5	N2	8.0																				0	0
12-15-81	41	1	3	1	5	N2	8.0																				0	0
12-15-81	41	1	2	3	5	N2	8.0																				0	0
12-15-81	41	1	9	3	5	N2	19.0																				0	0
12-15-81	41	1	3	2	5	D1	7.0																				0	0
12-15-81	41	1	3	1	5	D1	7.0																				0	0
12-15-81	41	1	2	3	5	D1	7.0																				0	0
12-15-81	41	1	9	3	5	D1	7.0																				0	0

Appendix 2. Continued.

Sample parameters								Species/groups																			
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
12-15-81	41	1	3	2	5	D2	7.5																				0	0
12-15-81	41	1	3	1	5	D2	7.5																				0	0
12-15-81	41	1	2	3	5	D2	7.5																				0	0
12-15-81	41	1	9	3	5	D2	7.5																				0	0
12-15-81	41	1	3	2	5	N1	8.0																				0	0
12-15-81	41	1	3	1	5	N1	8.0																				0	0
12-15-81	41	1	2	3	5	N1	8.0																				0	0
12-15-81	41	1	9	3	5	N1	8.0																				0	0

Appendix 3. Densities (no./1000 m^3) for fish eggs and larvae entrained at the D.C. Cook Plant, southeastern Lake Michigan, 1982. Sample parameter codes are: Mpd (month period): consecutive number of the sample period during the annual sample program. Ser (series): (1) standard series, (2) supplemental sample, (3) problems-sample not used in calculations. Grt (grate): location of forebay grate, see Fig. 3 for reference. N/S (north/south): further designation of sampling location at each grate, (1) north, (2) south, (3) no designation, see Fig. 3 for reference. Dpt (depth): depth (m) of sampling in the forebay. Dl (diel): (N1) midnight to dawn, (D1) dawn to noon, (D2) noon to dusk, (N2) dusk to midnight, (LD and LN) long day or long night, samples extending beyond normal diel schedule, (OD and ON) other day or other night, sampling was performed at irregular intervals. Temp: temperature (C) of intake water when the sample was collected. Refer to Table 12 for species designation. Blank entries indicate zero densities.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
1-12-82	1	1	3	2	5	N1	10.4																				0	0
1-12-82	1	1	2	3	5	N1	10.7																				0	0
1-12-82	1	1	3	1	5	N1	10.7																				0	0
1-12-82	1	1	9	3	5	N1	10.7																				0	0
1-13-82	1	1	2	3	5	N2	11.0																				0	0
1-13-82	1	1	9	3	5	N2	10.7																				0	0
1-13-82	1	1	3	1	5	N2	11.3																				0	0
1-13-82	1	1	2	3	5	D1	9.0																				0	0
1-13-82	1	1	3	2	5	D1	9.0																				0	0
1-13-82	1	1	9	3	5	D1	9.5																				0	0
1-13-82	1	1	3	1	5	D1	10.5																				0	0
1-13-82	1	1	9	3	5	D2	9.8																				0	0
1-13-82	1	1	3	1	5	D2	9.9																				0	0
1-13-82	1	1	2	3	5	D2	9.2																				0	0
1-13-82	1	1	3	2	5	D2	10.5																				0	0
1-13-82	1	1	3	2	5	N2	9.8																				0	0
1-20-82	2	1	9	3	5	N1	3.0																				0	0
1-20-82	2	1	3	1	5	N1	3.0																				0	418
1-20-82	2	1	2	3	5	N1	3.0																				0	237
1-20-82	2	1	3	2	5	N1	3.0																				0	89
1-21-82	2	1	3	2	5	N2	3.0																				0	12
1-21-82	2	1	9	3	5	N2	3.0																				0	70
1-21-82	2	1	3	1	5	N2	3.0																				0	168
1-21-82	2	1	2	3	5	N2	3.0																				0	0
1-21-82	2	1	2	3	5	D1	3.0																				0	50
1-21-82	2	1	3	2	5	D1	3.0																				0	0
1-21-82	2	1	9	3	5	D1	3.0																				0	46
1-21-82	2	1	3	1	5	D1	3.0																				0	52
1-21-82	2	1	3	2	5	D2	4.0																				0	17
1-21-82	2	1	2	3	5	D2	4.0																				0	33
1-21-82	2	1	3	1	5	D2	4.0																				0	53
1-21-82	2	1	9	3	5	D2	4.0																				0	82
2-08-82	3	1	3	2	5	N1	2.5																				0	240

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
2-08-82	3	1	2	3	5	N1	1.3																				0	172
2-08-82	3	1	3	1	5	N1	1.2																				0	495
2-08-82	3	2	8	3	5	N1	1.6																				0	0
2-09-82	3	1	3	2	5	N2	1.7																				0	202
2-09-82	3	1	3	1	5	N2	1.5																				0	230
2-09-82	3	2	8	3	5	N2	1.5																				0	86
2-09-82	3	1	2	3	5	D1	1.7																				0	232
2-09-82	3	1	3	2	5	D1	1.8																				0	3849
2-09-82	3	1	3	1	5	D1	1.7																				0	0
2-09-82	3	2	8	3	5	D1	1.7																				0	0
2-09-82	3	1	3	2	5	D2	1.5																				0	3721
2-09-82	3	1	2	3	5	D2	1.5																				0	862
2-09-82	3	2	8	3	5	D2	1.5																				0	105
2-09-82	3	1	3	1	5	D2	1.5																				0	37
2-09-82	3	1	2	3	5	N2	1.4																				0	22
2-23-82	4	1	2	3	5	D2	0.5																				0	36
2-23-82	4	1	3	2	5	D2	0.5																				0	7789
2-23-82	4	2	8	3	5	D2	0.5																				0	0
2-23-82	4	1	3	1	5	D2	0.5																				0	0
2-23-82	4	1	2	3	5	N1	0.0																				0	0
2-23-82	4	1	3	2	5	N1	0.0																				0	1447
2-23-82	4	2	8	3	5	N1	0.0																				0	57
2-23-82	4	1	3	1	5	N1	0.0																				0	0
2-24-82	4	1	2	3	5	N2	0.0																				0	0
2-24-82	4	1	3	2	5	N2	0.0																				0	0
2-24-82	4	2	8	3	5	N2	0.0																				0	50
2-24-82	4	1	3	1	5	N2	0.0																				0	0
2-24-82	4	1	3	2	5	D1	0.0																				0	0
2-24-82	4	1	2	3	5	D1	0.0																				0	0
2-24-82	4	2	8	3	5	D1	0.0																				0	0
2-24-82	4	1	3	1	5	D1	0.0																				0	0
3-08-82	5	1	3	2	5	N1	2.3																				0	0
3-08-82	5	1	2	3	5	N1	2.2																				0	0
3-08-82	5	1	3	1	5	N1	1.8																				0	0
3-08-82	5	1	9	3	5	N1	2.1																				0	0
3-08-82	5	1	3	2	5	N2	0.2																				0	0
3-08-82	5	1	9	3	5	N2	0.2																				0	0
3-09-82	5	1	2	3	5	N2	0.4																				0	31
3-09-82	5	1	3	1	5	N2	0.2																				0	29
3-09-82	5	1	9	3	5	D1	0.2																				0	0
3-09-82	5	1	3	2	5	D1	0.3																				0	0

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
3-09-82	5	1	2	3	5	D1	0.2																				0	0
3-09-82	5	1	3	1	5	D1	0.2																				0	0
3-09-82	5	1	3	2	5	D2	0.3																				0	0
3-09-82	5	1	2	3	5	D2	0.2																				0	0
3-09-82	5	1	9	3	5	D2	0.2																				0	0
3-09-82	5	1	3	1	5	D2	0.2																				0	0
3-24-82	6	1	2	3	5	D2	4.0																				0	0
3-24-82	6	1	3	2	5	D2	4.0																				0	0
3-24-82	6	1	9	3	5	D2	4.0																				0	0
3-24-82	6	1	3	1	5	D2	4.0																				0	0
3-24-82	6	1	3	2	5	N1	3.5																				0	20
3-24-82	6	1	2	3	5	N1	3.5																				0	19
3-24-82	6	1	3	1	5	N1	3.5																				0	0
3-24-82	6	1	9	3	5	N1	3.5																				0	0
3-25-82	6	1	2	3	5	N2	3.0																				0	0
3-25-82	6	1	3	2	5	N2	3.0																				0	0
3-25-82	6	1	9	3	5	N2	3.0																				0	0
3-25-82	6	1	3	1	5	N2	3.0																				0	0
3-25-82	6	1	2	3	5	D1	3.0																				0	0
3-25-82	6	1	3	2	5	D1	3.0																				0	0
3-25-82	6	1	9	3	5	D1	3.0																				0	0
3-25-82	6	1	3	1	5	D1	3.0																				0	0
4-12-82	7	1	3	2	5	N1	9.2																				0	0
4-12-82	7	1	2	3	5	N1	8.8																				0	0
4-12-82	7	1	9	3	5	N1	8.9																				0	0
4-12-82	7	1	3	1	5	N1	8.7																				0	0
4-13-82	7	1	3	2	5	N2	3.4																				0	0
4-13-82	7	1	2	3	5	N2	4.2																				0	0
4-13-82	7	1	9	3	5	N2	3.8																				0	0
4-13-82	7	1	3	1	5	N2	4.0																				0	0
4-13-82	7	1	3	2	5	D1	8.0																				0	0
4-13-82	7	1	9	3	5	D1	7.5																				0	0
4-13-82	7	1	2	3	5	D1	7.8																				0	0
4-13-82	7	1	3	1	5	D1	6.8																				0	0
4-13-82	7	1	3	2	5	D2	3.9																				0	0
4-13-82	7	1	2	3	5	D2	4.2																				0	0
4-13-82	7	1	9	3	5	D2	4.0																				0	0
4-13-82	7	1	3	1	5	D2	4.0																				0	0
4-26-82	8	1	3	2	5	N1	6.5																				0	32
4-26-82	8	1	3	1	5	N1	6.5																				0	314

Appendix 3. Continued.

Sample parameters								Species/groups																			
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
4-26-82	8	1	2	3	5	N1	6.5																				0	134
4-26-82	8	1	9	3	5	N1	6.5																				0	653
4-27-82	8	1	9	3	5	N2	6.0																				0	17
4-27-82	8	1	9	3	5	D1	7.0																				0	144
4-27-82	8	1	2	3	5	D1	7.0																				0	17
4-27-82	8	1	3	1	5	D1	7.0																				0	91
4-27-82	8	1	3	2	5	D1	7.0																				0	119
4-27-82	8	1	3	1	5	D2	7.0																				0	447
4-27-82	8	1	2	3	5	D2	7.0																				0	495
4-27-82	8	1	3	2	5	D2	7.0																				0	483
4-27-82	8	1	9	3	5	D2	7.0																				0	675
4-27-82	8	1	2	3	5	N2	6.0																				0	108045
4-27-82	8	1	3	2	5	N2	6.0																				0	30
4-27-82	8	1	3	1	5	N2	6.0																				0	0
5-10-82	9	1	2	3	5	N1	12.7			91																	91	0
5-10-82	9	1	3	2	5	N1	13.8			286				85								28					399	0
5-10-82	9	1	3	1	5	N1	13.8			129					43												172	43
5-10-82	9	1	9	3	5	N1	13.1			194				32													226	64
5-10-82	9	1	9	3	5	N2	13.4			19																	19	19
5-10-82	9	1	3	1	5	N2	13.3			144																	144	20
5-10-82	9	1	2	3	5	N2	13.3			66				65													131	0
5-10-82	9	1	3	2	5	N2	13.6			322				28													350	0
5-11-82	9	1	2	3	5	D1	13.5							15													15	0
5-11-82	9	1	3	2	5	D1	13.5			112				42													154	0
5-11-82	9	1	9	3	5	D1	13.6			54				91													145	0
5-11-82	9	1	3	1	5	D1	13.7			92																	92	0
5-11-82	9	1	2	3	5	D2	13.8			41																	41	10
5-11-82	9	1	3	2	5	D2	14.0			161																	161	19
5-11-82	9	1	9	3	5	D2	14.0			9				9													18	9
5-11-82	9	1	3	1	5	D2	14.0			12																	12	12
5-25-82	10	1	3	2	5	D2	13.0																				0	0
5-25-82	10	1	3	1	5	D2	14.0																				0	0
5-25-82	10	1	2	3	5	D2	14.5																				0	0
5-25-82	10	1	9	3	5	D2	14.0																				0	0
5-25-82	10	1	9	3	5	N1	13.5																				0	0
5-25-82	10	1	2	3	5	N1	13.0																				0	0
5-25-82	10	1	3	1	5	N1	13.5							25													25	77
5-25-82	10	1	3	2	5	N1	14.0			54						27											81	27
5-26-82	10	1	2	3	5	N2	13.0			17																	17	205
5-26-82	10	1	9	3	5	N2	13.5									13						13					26	55
5-26-82	10	1	3	2	5	N2	14.0			18				18													36	37

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
5-26-82	10	1	3	1	5	N2	13.5																				0	179
5-26-82	10	1	9	3	5	D1	12.7																				0	12
5-26-82	10	1	2	3	5	D1	12.0																				0	16
5-26-82	10	1	3	1	5	D1	13.0																				0	23
5-26-82	10	1	3	2	5	D1	13.0																				0	36
6-02-82	11	1	9	3	5	D2	16.0																				0	1460
6-02-82	11	1	3	2	5	D2	16.0	11	22																		33	1201
6-02-82	11	1	3	1	5	D2	16.5																				0	1329
6-02-82	11	1	2	3	5	D2	15.5																				0	1195
6-02-82	11	1	3	2	5	N1	13.0																				0	4085
6-02-82	11	1	3	1	5	N1	13.0	31																			31	12518
6-02-82	11	1	2	3	5	N1	13.0							56	56												112	14245
6-02-82	11	1	9	3	5	N1	13.0								27							27					54	15027
6-03-82	11	1	2	3	5	N2	12.5		36						18						18						72	11786
6-03-82	11	1	9	3	5	N2	12.8		16																		16	11766
6-03-82	11	1	3	2	5	N2	13.0		18													18					36	32306
6-03-82	11	1	3	1	5	N2	13.0	24						24		24											72	11920
6-03-82	11	1	3	1	5	D1	14.0																				0	4417
6-03-82	11	1	3	2	5	D1	14.0																				0	2391
6-03-82	11	1	2	3	5	D1	12.5																				0	4010
6-03-82	11	1	9	3	5	D1	13.5																				0	3209
6-07-82	12	1	3	1	5	D2	14.0	25	12																		37	239
6-07-82	12	1	3	2	5	D2	15.0	37																			37	103
6-07-82	12	1	2	3	5	D2	14.0							25													25	113
6-07-82	12	1	9	3	5	D2	14.3	11													22						33	392
6-07-82	12	1	3	2	5	N1	14.0	25	125					125													275	201
6-07-82	12	1	3	1	5	N1	14.0	26	78												26						130	208
6-07-82	12	1	2	3	5	N1	14.0	25	154					50	25												254	491
6-07-82	12	1	9	3	5	N1	14.0		45					22													67	250
6-08-82	12	1	3	2	5	N2	13.5	19						38													57	259
6-08-82	12	1	2	3	5	N2	14.0	39	19																		58	412
6-08-82	12	1	3	1	5	N2	14.5	81	41	20																	142	330
6-08-82	12	1	9	3	5	N2	14.0	36						18								18					72	772
6-08-82	12	1	3	2	5	D1	14.0	79	13												13						105	403
6-08-82	12	1	3	1	5	D1	14.0	84	14												28						126	756
6-08-82	12	1	2	3	5	D1	14.0	26	13												13						52	260
6-08-82	12	1	9	3	5	D1	14.0	24		12				24													60	252
6-10-82	13	1	3	2	5	D2	17.2	34																			34	2408
6-10-82	13	1	3	1	5	D2	17.0							24													24	1554
6-10-82	13	1	2	3	5	D2	18.0	24																			24	9652

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
6-10-82	13	1	9	3	5	D2	17.7	10																			10	43
6-10-82	13	1	3	2	5	N1	18.8	309	230					50		25											614	83173
6-10-82	13	1	3	1	5	N1	16.0	165	555	54																	774	116852
6-10-82	13	1	2	3	5	N1	17.7	81	216							27											324	68495
6-10-82	13	1	9	3	5	N1	17.5	126	151					277								50					604	47787
6-11-82	13	1	3	2	5	N2	18.2	126	378																		504	26031
6-11-82	13	1	3	1	5	N2	16.0	242	391					18													651	40620
6-11-82	13	1	2	3	5	N2	18.0	18	93					93													204	23246
6-11-82	13	1	9	3	5	N2	17.8	35	195							17											247	24898
6-11-82	13	1	3	2	5	D1	16.0	40	13					13													66	2071
6-11-82	13	1	3	1	5	D1	16.5																				0	2048
6-11-82	13	1	2	3	5	D1	15.5																				0	3066
6-11-82	13	1	9	3	5	D1	16.0							26													26	2789
6-16-82	14	1	3	2	5	D2	17.0	485		20	107																612	692
6-16-82	14	1	3	1	5	D2	17.8	92		11	58			45													206	605
6-16-82	14	1	2	3	5	D2	17.5	88		12	75																175	911
6-16-82	14	1	9	3	5	D2	17.4	281	12	12	75			36													416	1245
6-16-82	14	1	9	3	5	N1	18.1	209	23		23			23													278	11459
6-16-82	14	1	2	3	5	N1	17.8	233		29	117			175													554	44479
6-16-82	14	1	3	1	5	N1	18.3	517	273					30													820	35611
6-16-82	14	1	3	2	5	N1	18.4	1165	407	58	29			87													1746	56483
6-17-82	14	1	3	2	5	N2	18.2	1146	818	72	126					18											2180	90626
6-17-82	14	1	3	1	5	N2	18.3	508	410	19	57	19	19	96								19					1147	87181
6-17-82	14	1	2	3	5	N2	18.2	222	549																		771	99667
6-17-82	14	1	9	3	5	N2	18.2	254	194	58	39			371													916	88382
6-17-82	14	1	9	3	5	D1	18.1	65						13													78	1600
6-17-82	14	1	2	3	5	D1	18.1	205	18	18				36													277	6229
6-17-82	14	1	3	1	5	D1	18.1	198	30																		228	1504
6-17-82	14	1	3	2	5	D1	18.1	338		14	28																380	3000
6-17-82	14	1	3	2	5	D2	17.0	63	21		42																126	3565
6-17-82	14	1	3	1	5	D2	17.8	99		12	36																147	1120
6-17-82	14	1	2	3	5	D2	18.7	13						39													52	751
6-17-82	14	1	3	2	5	N1	19.0	191		152																	343	22550
6-17-82	14	1	3	1	5	N1	18.6	461	23	23				23													530	33558
6-17-82	14	1	2	3	5	N1	18.9	425	75	25																	525	33210
6-17-82	14	1	9	3	5	N1	18.8	477	42	21	21			128													689	20617
6-18-82	14	1	9	3	5	N2	19.8	119	17	34				51													221	25303
6-18-82	14	1	3	1	5	N2	19.8	533	76	135	77			59													880	27903
6-18-82	14	1	3	2	5	N2	19.8	562	99	231	165																1057	22963
6-18-82	14	1	2	3	5	N2	19.7	545	160	120	40			20													885	32634
6-18-82	14	1	3	2	5	D1	19.5	356		22																	378	2773
6-18-82	14	1	3	1	5	D1	19.4	101			14																115	3514

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
6-18-82	14	1	2	3	5	D1	19.5	150		30				15													195	2746
6-18-82	14	1	9	3	5	D1	19.5	77						15													92	2575
6-23-82	15	3	3	2	5	D2	19.2	124			62																186	933
6-23-82	15	1	3	1	5	D2	20.1	66						16													82	554
6-23-82	15	1	2	3	5	D2	19.9	170	17	17																	204	500
6-23-82	15	1	9	3	5	D2	19.7	17			34																51	277
6-23-82	15	1	9	3	5	N1	18.5							57													57	13274
6-23-82	15	1	2	3	5	N1	18.1	306		25	50			25													406	24910
6-23-82	15	1	3	1	5	N1	18.8	75	150	100	25																350	16791
6-23-82	15	1	3	2	5	N1	18.7	388	388	55	55																886	36420
6-24-82	15	1	3	2	5	N2	18.8	282	932	201	162																1577	38966
6-24-82	15	1	2	3	5	N2	18.2	113	318																		431	33702
6-24-82	15	1	3	1	5	N2	18.6	323	233	184	23			138									116				1017	40131
6-24-82	15	1	9	3	5	N2	18.5		147	49				269													465	8800
6-24-82	15	1	9	3	5	D1	18.3	11						22													33	1201
6-24-82	15	1	2	3	5	D1	18.2	28		28				14													70	2009
6-24-82	15	1	3	1	5	D1	18.4		13																		13	1549
6-24-82	15	1	3	2	5	D1	18.4	84						28													112	2880
6-24-82	15	1	3	2	5	D2	18.7	158																			158	1385
6-24-82	15	1	3	1	5	D2	19.0	42	14																		56	931
6-24-82	15	1	2	3	5	D2	19.5	30						15													45	811
6-24-82	15	1	9	3	5	D2	19.1	13						13													26	319
6-24-82	15	1	9	3	5	N1	19.9	133	171					266									95				665	52729
6-24-82	15	1	2	3	5	N1	19.2	303	330					127													760	54335
6-24-82	15	1	3	1	5	N1	20.4	48	240	48	24			48													408	66062
6-24-82	15	1	3	2	5	N1	20.1	465	724	204	51		51														1495	38483
6-25-82	15	1	3	2	5	N2	19.9	400	266	88	222																976	14558
6-25-82	15	1	2	3	5	N2	19.8	350	25		25			100									75				575	14719
6-25-82	15	1	3	1	5	N2	20.1	146	245	48	146			48									196				829	10389
6-25-82	15	1	9	3	5	N2	19.9	112	112	28	197			56													505	14433
6-25-82	15	1	9	3	5	D1	18.7	22						22													44	913
6-25-82	15	1	2	3	5	D1	18.6	37																			37	958
6-25-82	15	1	3	1	5	D1	19.0	92		13				145													250	1234
6-25-82	15	1	3	2	5	D1	18.7	220			54			27													301	1720
6-29-82	16	1	3	2	5	D2	20.3	169	21		21			42													253	1998
6-29-82	16	1	3	1	5	D2	20.2	122						74													196	2274
6-29-82	16	1	2	3	5	D2	19.0	141	14					28													183	3136
6-29-82	16	1	9	3	5	D2	19.8	114						22													136	2887
6-29-82	16	1	9	3	5	N1	20.0	260	26					26								26					338	40933
6-29-82	16	1	2	3	5	N1	19.9	743	111					297													1151	37136
6-29-82	16	1	3	2	5	N1	19.8	2738	118					297													3153	61446

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
6-29-82	16	1	3	1	5	N1	20.3	1070	32					160									32				1294	48970
6-29-82	16	1	3	2	5	N2	20.0	256					64	128													448	10632
6-30-82	16	1	2	3	5	N2	19.8	299						46								23					368	14408
6-30-82	16	1	3	1	5	N2	19.4	80						161													241	16942
6-30-82	16	1	9	3	5	N2	19.7	156						135													291	9040
6-30-82	16	1	9	3	5	D1	18.1	36																			36	771
6-30-82	16	1	2	3	5	D1	18.0	94			26																120	3652
6-30-82	16	1	3	1	5	D1	18.1	23	11		11			11													56	2391
6-30-82	16	1	3	2	5	D1	18.4	514	16	16	16																562	3995
6-30-82	16	1	3	2	5	D2	17.0	362			24																386	1091
6-30-82	16	1	3	1	5	D2	16.6	264																			264	659
6-30-82	16	1	2	3	5	D2	16.3	57																			57	190
6-30-82	16	1	9	3	5	D2	16.7	60						15													75	90
6-30-82	16	1	9	3	5	N1	17.1	261	423					261									20				965	42290
6-30-82	16	1	2	3	5	N1	17.2	499	99	99	66			66													829	29794
6-30-82	16	1	3	1	5	N1	17.1	1053	405	135			27	297									135				2052	47211
6-30-82	16	1	3	2	5	N1	17.1	1273	714		79			318													2384	29435
7-01-82	16	1	3	2	5	N2	17.3	991	474					516													1981	114303
7-01-82	16	1	2	3	5	N2	17.9	497	885				109														1491	147043
7-01-82	16	1	3	1	5	N2	16.5	313	563					179													1055	124355
7-01-82	16	1	9	3	5	N2	17.2	378	860					75													1313	100894
7-01-82	16	1	9	3	5	D1	16.8	40	41					30													111	4086
7-01-82	16	1	2	3	5	D1	16.9	46	30																		76	7630
7-01-82	16	1	3	2	5	D1	16.9	319	52					53													424	5256
7-01-82	16	1	3	1	5	D1	16.6	272	13																		285	2884
7-06-82	17	1	3	2	5	D2	20.4	150						45													195	480
7-06-82	17	1	3	1	5	D2	20.0	250	12																		262	456
7-06-82	17	1	2	3	5	D2	20.0	327																			327	2244
7-06-82	17	2	8	3	5	D2	20.1	247	38																		285	865
7-06-82	17	2	3	3	5	N1	20.6	907	99																		1006	13367
7-06-82	17	1	2	3	5	N1	20.6	1027	84																		1111	9611
7-06-82	17	1	3	1	5	N1	20.5	652	29					29													710	7903
7-06-82	17	1	3	2	5	N1	20.7	1460	37																		1497	7192
7-07-82	17	1	3	2	5	N2	20.2	731	170																		901	4964
7-07-82	17	1	3	1	5	N2	20.2	401	44																		445	5701
7-07-82	17	1	2	3	5	N2	20.1	918	24					24													966	5873
7-07-82	17	2	8	3	5	N2	20.2	1619	414																		2033	9449
7-07-82	17	2	8	3	5	D1	21.1	836	66					110													1012	969
7-07-82	17	1	2	3	5	D1	21.2	551	67																		618	769
7-07-82	17	1	3	1	5	D1	21.1	380																			380	1141
7-07-82	17	1	3	2	5	D1	21.1	997																			997	957
7-07-82	17	1	9	3	5	D2	20.2	386						192													578	142

Appendix 3. Continued.

														Species/groups														
Sample parameters																												
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
7-07-82	17	1	3	1	5	D2	20.2	60																			60	161
7-07-82	17	1	3	2	5	D2	20.2	527																			527	94
7-07-82	17	1	2	3	5	D2	20.3	78																			78	13
7-07-82	17	1	9	3	5	N1	20.4	607	66					66													739	4268
7-07-82	17	1	3	2	5	N1	20.4	428	56																		484	6109
7-07-82	17	1	3	1	5	N1	20.4	1132						100													1232	12870
7-07-82	17	1	2	3	5	N1	20.4	564						73													637	4611
7-08-82	17	1	9	3	5	N2	20.9	536	56					56													648	8988
7-08-82	17	1	3	2	5	N2	20.8	456						72													528	9116
7-08-82	17	1	3	1	5	N2	20.8	80						81													161	10920
7-08-82	17	1	2	3	5	N2	21.0	276	23					46													345	6583
7-08-82	17	1	9	3	5	D1	20.6	167						15													182	437
7-08-82	17	1	3	2	5	D1	20.8	272						36													308	1308
7-08-82	17	1	3	1	5	D1	20.5	262																			262	713
7-08-82	17	1	2	3	5	D1	20.5	34																			34	451
7-13-82	18	1	3	2	5	D2	22.0	40																			40	593
7-13-82	18	2	8	3	5	D2	22.2																				0	1277
7-13-82	18	1	3	1	5	D2	22.4	25																			25	702
7-13-82	18	1	2	3	5	D2	22.3	26																			26	1005
7-13-82	18	2	8	3	5	N1	22.5	308																			308	31627
7-13-82	18	1	3	1	5	N1	22.5	27																			27	5165
7-13-82	18	1	3	2	5	N1	22.5	422	30																		452	17712
7-13-82	18	1	2	3	5	N1	22.5	348																			348	12963
7-14-82	18	2	8	3	5	OD	22.5	617					12														629	26217
7-14-82	18	2	3	1	5	OD	22.5	203																			203	13594
7-14-82	18	2	3	2	5	OD	22.5	390																			390	23486
7-14-82	18	2	2	3	5	OD	22.5	402					9														411	9607
7-14-82	18	1	2	3	5	D2	22.0	135																			135	754
7-14-82	18	1	3	2	5	D2	22.0	327						109													436	2508
7-14-82	18	1	3	1	5	D2	22.0	409	12					72													493	2111
7-14-82	18	1	9	3	5	D2	22.0	129						100													229	2375
7-14-82	18	1	3	1	5	N1	22.6	705						54													759	13234
7-14-82	18	1	3	2	5	N1	22.7	644																			644	15006
7-14-82	18	1	2	3	5	N1	22.6	871																			871	17507
7-14-82	18	1	9	3	5	N1	22.6	935						87													1022	27172
7-15-82	18	1	2	3	5	N2	22.6	1167																			1167	28235
7-15-82	18	1	3	1	5	N2	22.6	646																			646	37592
7-15-82	18	1	3	2	5	N2	22.6	872																			872	49505
7-15-82	18	1	9	3	5	N2	22.6	417						52													469	13467
7-15-82	18	1	9	3	5	D1	22.6	400																			400	2705
7-15-82	18	1	3	1	5	D1	22.8	205																			205	2297
7-15-82	18	1	2	3	5	D1	22.6	72																			72	1273

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
7-15-82	18	1	3	2	5	D1	22.6	514						514													1028	3855
7-16-82	18	1	3	2	5	N2	23.4	267																			267	40384
7-16-82	18	1	3	1	5	N2	23.4	116																			116	21912
7-16-82	18	1	2	3	5	N2	23.4	420	22					22													464	15998
7-16-82	18	2	8	3	5	N2	23.4	475						50													525	21778
7-16-82	18	2	8	3	5	D1	23.6	195						49													244	1586
7-16-82	18	1	3	1	5	D1	23.8	390																			390	2785
7-16-82	18	1	2	3	5	D1	23.6	19																			19	719
7-16-82	18	1	3	2	5	D1	23.6																				0	61
7-20-82	19	1	3	2	5	D2	23.0	28																			28	226
7-20-82	19	1	3	1	5	D2	23.0																				0	199
7-20-82	19	1	2	3	5	D2	23.0	35																			35	175
7-20-82	19	1	9	3	5	D2	23.0	16																			16	228
7-20-82	19	1	9	3	5	N1	22.3	187		31				62													280	722
7-20-82	19	1	3	2	5	N1	22.3		26					26													52	187
7-20-82	19	1	3	1	5	N1	22.3		25																		25	76
7-20-82	19	1	2	3	5	N1	22.3	31																			31	125
7-21-82	19	2	3	1	5	OD	21.3																				0	1769
7-21-82	19	2	2	3	5	OD	21.3	80																			80	1839
7-21-82	19	1	9	3	5	D2	22.2																				0	112
7-21-82	19	1	3	2	5	D2	22.2	12																			12	161
7-21-82	19	1	2	3	5	D2	22.2	15																			15	15
7-21-82	19	1	9	3	5	N1	22.1	135																			135	3284
7-21-82	19	1	3	2	5	N1	22.1	42																			42	1913
7-21-82	19	1	3	1	5	N1	22.1																				0	997
7-21-82	19	1	2	3	5	N1	22.1																				0	2578
7-21-82	19	2	9	3	5	OD	21.3	22																			22	6600
7-21-82	19	2	3	2	5	OD	21.3	40																			40	1793
7-22-82	19	1	3	1	5	N2	19.0	40																			40	7053
7-22-82	19	1	9	3	5	N2	19.0	218																			218	13027
7-22-82	19	1	3	2	5	N2	19.0	50																			50	21602
7-22-82	19	1	2	3	5	N2	19.0	87						29													116	2615
7-22-82	19	1	9	3	5	D1	20.3	15																			15	430
7-22-82	19	1	3	2	5	D1	20.3	14																			14	470
7-22-82	19	1	3	1	5	D1	20.3																				0	699
7-22-82	19	1	2	3	5	D1	20.3																				0	396
7-23-82	19	1	3	2	5	N2	8.7																				0	333
7-23-82	19	2	8	3	5	N2	8.7	22																			22	889
7-23-82	19	1	3	1	5	N2	8.7						18	36				18									72	548
7-23-82	19	1	2	3	5	N2	8.7																				0	255
7-23-82	19	2	8	3	5	D1	8.2	32																			32	49
7-23-82	19	1	3	2	5	D1	8.2	14																			14	84

Appendix 3. Continued.

Date	Mpd	Ser	Grt	N/S	Dpt	Dl	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
7-23-82	19	1	3	1	5	D1	8.2																				0	211
7-23-82	19	1	2	3	5	D1	8.2																				0	69
7-26-82	20	2	8	3	5	N1	22.9	217						73													290	613
7-26-82	20	1	3	1	5	N1	22.9	60						20													80	435
7-26-82	20	1	2	3	5	N1	22.9	50						25													75	733
7-26-82	20	1	3	2	5	N1	22.9	100	40																		140	426
7-27-82	20	2	8	3	5	N2	23.0	23																			23	5503
7-27-82	20	1	3	2	5	N2	23.0	54	18																		72	6468
7-27-82	20	1	3	1	5	N2	23.0	74																			74	6826
7-27-82	20	1	2	3	5	N2	23.0	24	24																		48	4745
7-27-82	20	1	8	3	5	N2	23.5	36																			36	400
7-27-82	20	1	3	2	5	D1	23.5	13	27					13													53	436
7-27-82	20	1	3	1	5	D1	23.5	28																			28	376
7-27-82	20	1	2	3	5	D1	23.5	54																			54	271
7-27-82	20	1	2	3	5	D2	18.4	26						13													39	0
7-27-82	20	1	9	3	5	D2	21.6	45						15													60	260
7-27-82	20	1	3	2	5	D2	23.2	22																			22	141
7-27-82	20	1	3	1	5	D2	23.2	24						12													36	195
7-28-82	20	1	3	1	5	D2	19.5																				0	294
7-28-82	20	1	3	2	5	D2	19.5																				0	93
7-28-82	20	1	2	3	5	D2	19.5	15																			15	166
7-28-82	20	2	8	3	5	D2	19.5	17																			17	174
7-28-82	20	2	8	3	5	N1	18.1	25																			25	206
7-28-82	20	1	3	2	5	N1	18.1	34					17														51	197
7-28-82	20	1	3	1	5	N1	18.1																				0	216
7-28-82	20	1	2	3	5	N1	18.1	63					63														126	218
7-29-82	20	2	8	3	5	N2	16.8	46					70														116	94
7-29-82	20	1	3	1	5	N2	16.8																				0	375
7-29-82	20	1	3	2	5	N2	16.8	42																			42	214
7-29-82	20	1	2	3	5	N2	16.8	88																			88	89
7-29-82	20	2	8	3	5	D1	15.0	17																			17	338
7-29-82	20	1	3	2	5	D1	15.0	43						14													57	489
7-29-82	20	1	3	1	5	D1	15.0																				0	129
7-29-82	20	1	2	3	5	D1	15.0	30																			30	188
8-18-82	21	1	3	2	5	D2	21.0																				0	0
8-18-82	21	1	3	1	5	D2	21.0																				0	0
8-18-82	21	1	2	3	5	D2	21.0	38						19													57	0
8-18-82	21	2	8	3	5	D2	21.0																				0	0
8-18-82	21	2	8	3	5	N1	21.5							61													61	0
8-18-82	21	1	3	2	5	N1	21.5	21																			21	0
8-18-82	21	1	3	1	5	N1	21.5																				0	0

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
8-18-82	21	1	2	3	5	N1	21.5	34																			34	0
8-19-82	21	1	2	3	5	N2	20.9	322		46		23	23														414	0
8-19-82	21	1	3	1	5	N2	20.9	55																			55	0
8-19-82	21	1	3	2	5	N2	20.9																				0	0
8-19-82	21	2	8	3	5	N2	20.9	285		57																	342	0
8-19-82	21	2	8	3	5	D1	21.8																				0	0
8-19-82	21	1	3	2	5	D1	21.8	45																			45	0
8-19-82	21	1	3	1	5	D1	21.8	96		16																	112	0
8-19-82	21	1	2	3	5	D1	21.8	22																			22	0
8-19-82	21	1	3	2	5	D2	22.6																				0	11
8-19-82	21	1	2	3	5	D2	22.6																				0	0
8-19-82	21	1	3	1	5	D2	22.6																				0	0
8-19-82	21	2	8	3	5	D2	22.6	30																			30	0
8-19-82	21	2	8	3	5	N1	22.7																				0	0
8-19-82	21	1	3	2	5	N1	22.7	38						19													57	0
8-19-82	21	1	3	1	5	N1	22.7																				0	0
8-19-82	21	1	2	3	5	N1	22.7	112				28															140	0
8-20-82	21	1	3	2	5	N2	22.8	53																			53	0
8-20-82	21	1	2	3	5	N2	22.8	133					19														152	0
8-20-82	21	2	8	3	5	N2	22.8			70																	70	0
8-20-82	21	1	3	1	5	N2	22.8																				0	0
8-20-82	21	2	8	3	5	D1	22.8																				0	0
8-20-82	21	1	3	2	5	D1	22.8																				0	0
8-20-82	21	1	3	1	5	D1	22.8	36						18													54	0
8-20-82	21	1	2	3	5	D1	22.8	25			25																50	0
8-23-82	22	1	3	2	5	N1	22.1																				0	0
8-23-82	22	1	3	1	5	N1	22.1						20														20	0
8-23-82	22	1	2	3	5	N1	22.1																				0	0
8-23-82	22	2	8	3	5	N1	22.1																				0	0
8-24-82	22	2	8	3	5	N2	22.0																				0	0
8-24-82	22	1	3	2	5	N2	22.0	17																			17	0
8-24-82	22	1	3	1	5	N2	22.0																				0	0
8-24-82	22	1	2	3	5	N2	22.0	25																			25	0
8-24-82	22	1	3	2	5	D1	22.0																				0	0
8-24-82	22	1	3	1	5	D1	22.0																				0	0
8-24-82	22	1	2	3	5	D1	22.0	42																			42	0
8-24-82	22	2	8	3	5	D1	22.0																				0	0
8-24-82	22	2	8	3	5	D2	22.2																				0	0
8-24-82	22	1	3	2	5	D2	22.2	11																			11	0
8-24-82	22	1	3	1	5	D2	22.2																				0	0
8-24-82	22	1	2	3	5	D2	22.2	15																			15	0
8-24-82	22	1	3	2	5	N1	22.1																				0	0

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
8-24-82	22	1	3	1	5	N1	22.1																				0	0
8-24-82	22	1	2	3	5	N1	22.1					26															26	0
8-24-82	22	2	8	3	5	N1	23.2																				0	0
8-25-82	22	1	3	2	5	N2	22.0	16																			16	0
8-25-82	22	1	2	3	5	N2	22.0																				0	0
8-25-82	22	2	8	3	5	N2	22.0	38																			38	0
8-25-82	22	1	3	1	5	N2	22.0																				0	0
8-25-82	22	2	8	3	5	D1	21.7			54																	54	0
8-25-82	22	1	3	2	5	D1	21.7																				0	0
8-25-82	22	1	3	1	5	D1	21.7	28						28													56	14
8-25-82	22	1	2	3	5	D1	21.7																				0	0
8-25-82	22	1	3	2	5	D2	21.2																				0	0
8-25-82	22	1	2	3	5	D2	21.2																				0	0
8-25-82	22	2	8	3	5	D2	21.2			25																	25	0
8-25-82	22	1	3	1	5	D2	21.2																				0	0
9-01-82	23	1	2	3	5	D2	21.3																				0	0
9-01-82	23	1	3	1	5	D2	21.3																				0	0
9-01-82	23	1	3	2	5	D2	21.3		14																		14	0
9-01-82	23	2	8	3	5	D2	21.3																				0	0
9-01-82	23	2	8	3	5	LN	21.0																				0	0
9-01-82	23	2	3	2	5	LN	21.0					8															8	0
9-01-82	23	2	3	1	5	LN	21.0							8													8	0
9-01-82	23	2	2	3	5	LN	21.0																				0	0
9-02-82	23	2	8	3	5	D1	20.9																				0	0
9-02-82	23	1	3	2	5	D1	20.9																				0	0
9-02-82	23	1	2	3	5	D1	20.9																				0	0
9-02-82	23	1	3	1	5	D1	20.9																				0	0
9-02-82	23	1	2	3	5	N1	21.7																				0	0
9-02-82	23	1	3	1	5	N1	21.7																				0	0
9-02-82	23	1	3	2	5	N1	21.7																				0	0
9-02-82	23	1	9	3	5	N1	21.7																				0	0
9-02-82	23	2	8	3	5	N2	20.9	25																			25	0
9-03-82	23	1	3	2	5	N2	20.9																				0	0
9-03-82	23	1	3	1	5	N2	20.9																				0	0
9-03-82	23	1	2	3	5	N2	20.9																				0	0
9-07-82	24	2	8	3	5	D2	20.1																				0	0
9-07-82	24	1	2	3	5	D2	20.1																				0	0
9-07-82	24	1	3	2	5	D2	20.1																				0	0
9-07-82	24	1	3	1	5	D2	20.1																				0	0
9-07-82	24	2	8	3	5	N1	20.0																				0	0
9-07-82	24	1	3	2	5	N1	20.0																				0	0

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
9-07-82	24	1	3	1	5	N1	20.0																				0	0
9-07-82	24	1	2	3	5	N1	20.0																				0	0
9-08-82	24	1	9	3	5	N2	20.0																				0	0
9-08-82	24	1	2	3	5	N2	20.0																				0	0
9-08-82	24	1	3	1	5	N2	20.0																				0	0
9-08-82	24	1	3	2	5	N2	20.0																				0	0
9-08-82	24	1	3	2	5	D1	19.7																				0	0
9-08-82	24	1	9	3	5	D1	19.7																				0	0
9-08-82	24	1	3	1	5	D1	19.7																				0	0
9-08-82	24	1	2	3	5	D1	19.7																				0	0
10-05-82	25	3	9	3	5	D2	17.8																				0	0
10-05-82	25	3	3	1	5	D2	17.8																				0	0
10-05-82	25	1	3	2	5	D2	17.8																				0	0
10-05-82	25	1	2	3	5	D2	17.8	22																			22	0
10-05-82	25	1	3	2	5	N1	19.8					20															20	0
10-05-82	25	1	3	1	5	N1	19.8																				0	0
10-05-82	25	1	2	3	5	N1	19.8					28															28	0
10-05-82	25	3	9	3	5	N1	19.8																				0	0
10-06-82	25	1	3	1	5	N2	19.4					46															46	0
10-06-82	25	1	2	3	5	N2	19.4					20															20	0
10-06-82	25	1	9	3	5	N2	19.4							13													13	0
10-06-82	25	1	3	2	5	D1	19.9																				0	0
10-06-82	25	1	3	1	5	D1	19.9																				0	0
10-06-82	25	1	2	3	5	D1	19.9																				0	0
10-06-82	25	1	9	3	5	D1	19.9																				0	0
10-06-82	25	1	3	2	5	N2	19.4																				0	0
10-19-82	26	1	9	3	5	D2	15.2																				0	0
10-19-82	26	1	2	3	5	D2	15.2																				0	0
10-19-82	26	1	3	1	5	D2	15.2	20																			20	0
10-19-82	26	1	3	2	5	D2	15.2																				0	0
10-19-82	26	1	3	1	5	N1	15.1																				0	0
10-19-82	26	1	3	2	5	N1	15.1																				0	0
10-19-82	26	1	9	3	5	N1	15.1																				0	0
10-19-82	26	1	2	3	5	N1	15.1																				0	0
10-20-82	26	1	9	3	5	N2	15.1																				0	0
10-20-82	26	1	2	3	5	N2	15.1																				0	0
10-20-82	26	1	3	2	5	N2	15.1																				0	0
10-20-82	26	1	3	1	5	N2	15.1																				0	0
10-20-82	26	1	9	3	5	D1	13.2																				0	0
10-20-82	26	1	2	3	5	D1	13.2																				0	0
10-20-82	26	1	3	1	5	D1	13.2																				0	0

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
10-20-82	26	1	3	2	5	D1	13.2																				0	0
11-03-82	27	1	9	3	5	D2	15.8																				0	0
11-03-82	27	1	3	2	5	D2	15.8																				0	0
11-03-82	27	1	3	1	5	D2	15.8																				0	0
11-03-82	27	1	2	3	5	D2	15.8																				0	0
11-03-82	27	1	3	1	5	N1	14.3																				0	0
11-03-82	27	1	3	2	5	N1	14.3																				0	0
11-03-82	27	1	2	3	5	N1	14.3																				0	0
11-03-82	27	1	9	3	5	N1	14.3																				0	0
11-04-82	27	1	9	3	5	N2	12.3																				0	0
11-04-82	27	1	2	3	5	N2	12.3																				0	0
11-04-82	27	1	3	2	5	N2	12.3																				0	0
11-04-82	27	1	3	1	5	N2	12.3																				0	0
11-04-82	27	1	3	2	5	D1	12.2																				0	0
11-04-82	27	1	3	1	5	D1	12.2																				0	0
11-04-82	27	1	2	3	5	D1	12.2																				0	0
11-04-82	27	1	9	3	5	D1	12.2																				0	0
11-15-82	28	1	2	3	5	D2	10.8																				0	0
11-15-82	28	1	3	2	5	D2	10.8																				0	19
11-15-82	28	1	9	3	5	D2	10.8																				0	0
11-15-82	28	1	3	1	5	D2	10.8																				0	0
11-15-82	28	1	3	2	5	N1	9.6																				0	0
11-15-82	28	1	3	1	5	N1	9.6																				0	0
11-15-82	28	1	2	3	5	N1	9.6																				0	0
11-15-82	28	1	9	3	5	N1	9.6																				0	0
11-16-82	28	1	9	3	5	N2	8.4																				0	0
11-16-82	28	1	3	2	5	N2	8.4																				0	0
11-16-82	28	1	2	3	5	N2	8.4																				0	0
11-16-82	28	1	3	1	5	N2	8.4																				0	0
11-16-82	28	1	3	2	5	D1	8.8																				0	0
11-16-82	28	1	3	1	5	D1	8.8																				0	0
11-16-82	28	1	2	3	5	D1	8.8																				0	0
11-16-82	28	1	9	3	5	D1	8.8																				0	0
12-08-82	29	1	3	2	5	D2	8.0																				0	0
12-08-82	29	1	9	3	5	D2	8.0																				0	0
12-08-82	29	1	2	3	5	D2	8.0																				0	0
12-08-82	29	1	3	1	5	D2	8.0																				0	0
12-08-82	29	1	9	3	5	N1	7.8																				0	0
12-08-82	29	1	2	3	5	N1	7.8																				0	0
12-08-82	29	1	3	1	5	N1	7.8																				0	0

Appendix 3. Continued.

Sample parameters								Species/groups																				
Date	Mpd	Ser	Grt	N/S	Dpt	D1	Temp C	AL	SP	SM	YP	TP	JD	XP	SS	MS	CP	NS	FS	QL	BR	UC	XM	XC	XE	XX	Total larvae	Eggs
12-08-82	29	1	3	2	5	N1	7.8																				0	0
12-09-82	29	1	9	3	5	N2	6.3																				0	0
12-09-82	29	1	2	3	5	N2	6.3																				0	0
12-09-82	29	1	3	1	5	N2	6.3																				0	0
12-09-82	29	1	3	2	5	N2	6.3																				0	0
12-09-82	29	1	9	3	5	D1	7.3																				0	0
12-09-82	29	1	2	3	5	D1	7.3																				0	0
12-09-82	29	1	3	1	5	D1	7.3																				0	0
12-09-82	29	1	3	2	5	D1	7.3																				0	0
12-21-82	30	1	3	2	5	D2	4.3																				0	0
12-21-82	30	1	2	3	5	D2	4.3																				0	0
12-21-82	30	1	9	3	5	D2	4.3																				0	0
12-21-82	30	1	3	1	5	D2	4.3																				0	0
12-21-82	30	1	3	2	5	N1	4.3																				0	0
12-21-82	30	1	3	1	5	N1	4.3																				0	0
12-21-82	30	1	2	3	5	N1	4.3																				0	0
12-21-82	30	1	9	3	5	N1	4.3																				0	0
12-22-82	30	1	9	3	5	N2	5.7																				0	0
12-22-82	30	1	2	3	5	N2	5.7																				0	0
12-22-82	30	1	3	2	5	N2	5.7																				0	0
12-22-82	30	1	3	1	5	N2	5.7																				0	0
12-22-82	30	1	3	2	5	D1	5.8																				0	0
12-22-82	30	1	3	1	5	D1	5.8																				0	0
12-22-82	30	1	2	3	5	D1	5.8																				0	0
12-22-82	30	1	9	3	5	D1	5.8																				0	0

Appendix 4. Densities (no./1000 m³) for fish eggs and larvae collected at beach (A, B, F) and open water (C, D, G, H, E, W, R) stations in Cook Plant study areas, southeastern Lake Michigan, 1980. See Fig. 1 for station locations. Date = month, day, year; Dl = diel period, D = day, N = night; Sta = station; Dpt = depth in meters, O = surface tow. See Table 12 for species corresponding to species codes.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-07-80	D	A	O	9.5													0	0
4-07-80	D	A	O	9.5													0	0
4-07-80	N	A	O	9.0													0	0
4-07-80	N	A	O	9.0													0	0
4-07-80	D	B	O	10.0													0	0
4-07-80	D	B	O	10.0													0	0
4-07-80	N	B	O	8.5													0	0
4-07-80	N	B	O	8.5													0	476
4-07-80	D	F	O	7.5													0	0
4-07-80	D	F	O	7.5													0	0
4-07-80	N	F	O	8.0													0	0
4-07-80	N	F	O	8.0													0	0
5-14-80	D	A	O	14.2			890	111									1001	0
5-14-80	D	A	O	14.2			600	120								QL: 240	960	0
5-14-80	N	A	O	13.5			206										206	0
5-14-80	N	A	O	13.5													0	95
5-14-80	D	B	O	13.5			153										153	0
5-14-80	D	B	O	13.5			329										329	164
5-14-80	N	B	O	12.6			215										215	0
5-14-80	N	B	O	12.6				196									196	0
5-14-80	D	F	O	14.3													0	0
5-14-80	D	F	O	14.3			250										250	125
5-14-80	N	F	O	14.0			328	493									821	0
5-14-80	N	F	O	14.0			168	168									336	0
6-09-80	D	A	O	16.7													0	1801
6-09-80	D	A	O	16.7													0	2314
6-09-80	N	A	O	15.3													0	666
6-09-80	N	A	O	15.3				121									121	1090

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	DI	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-09-80	D	B	0	13.5													0	0
6-09-80	D	B	0	13.5													0	0
6-09-80	N	B	0	13.5													0	24062
6-09-80	N	B	0	13.5		91		91									182	70160
6-09-80	D	F	0	14.0													0	0
6-09-80	D	F	0	14.0				117									117	0
6-09-80	N	F	0	14.0		97											97	293
6-09-80	N	F	0	14.0		238		119									357	0
7-07-80	D	A	0	17.5	27746	720											28466	0
7-07-80	D	A	0	17.5	20245	493											20738	987
7-08-80	N	A	0	17.5	2606	1807					144						4557	1086
7-08-80	N	A	0	17.5	3841	1566											5407	1725
7-07-80	D	B	0	17.2	15401	757											16158	0
7-07-80	D	B	0	17.2	15176	1355											16531	0
7-08-80	N	B	0	17.7	4218	1581											5799	603
7-08-80	N	B	0	17.7	5770	1598											7368	88
7-07-80	D	F	0	18.4	3962												3962	0
7-07-80	D	F	0	18.4	2807												2807	701
7-07-80	N	F	0	18.5	5068	1880											6948	289
7-07-80	N	F	0	18.5	4909	1753											6662	175
8-12-80	D	A	0	23.5		102											102	0
8-12-80	D	A	0	23.5												XP: 74	74	0
8-12-80	N	A	0	22.5		62											62	0
8-12-80	N	A	0	22.5	120	300											420	0
8-12-80	D	B	0	23.5													0	0
8-12-80	D	B	0	23.5	112												112	0
8-12-80	N	B	0	22.3	196	98											294	0
8-12-80	N	B	0	22.3	216												216	0

Appendix 4. Continued.

Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
Sample Parameters					Species/Groups													
8-12-80	D	F	0	23.5													0	0
8-12-80	D	F	0	23.5													0	0
8-12-80	N	F	0	23.0	92	736											828	0
8-12-80	N	F	0	23.0		936											936	0
9-08-80	D	A	0	23.0													0	0
9-08-80	D	A	0	23.0													0	0
9-08-80	N	A	0	21.4	139												139	0
9-08-80	N	A	0	21.4													0	0
9-08-80	D	B	0	27.0													0	0
9-08-80	D	B	0	27.0	139												139	0
9-08-80	N	B	0	21.7	115												115	0
9-08-80	N	B	0	21.7													0	0
9-08-80	D	F	0	23.8													0	0
9-08-80	D	F	0	23.8													0	0
9-08-80	N	F	0	23.0													0	0
9-08-80	N	F	0	23.0													0	0
10-13-80	D	A	0	14.0													0	0
10-13-80	D	A	0	14.0													0	66
10-13-80	N	A	0	12.0													0	0
10-13-80	N	A	0	12.0													0	0
10-13-80	D	B	0	14.0	207												207	0
10-13-80	D	B	0	14.0													0	0
10-13-80	N	B	0	13.0													0	0
10-13-80	N	B	0	13.0													0	0
10-13-80	D	F	0	12.0													0	0
10-13-80	D	F	0	12.0	121												121	0
10-13-80	N	F	0	12.0													0	0
10-13-80	N	F	0	12.0													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
11-13-80	D	A	0	7.6													0	0
11-13-80	D	A	0	7.6													0	0
11-12-80	N	A	0	6.5													0	0
11-12-80	N	A	0	6.5													0	0
11-13-80	D	B	0	7.4													0	0
11-13-80	D	B	0	7.4													0	0
11-12-80	N	B	0	6.7													0	0
11-12-80	N	B	0	6.7													0	0
11-13-80	D	F	0	7.0	123												123	0
11-13-80	D	F	0	7.0													0	0
11-12-80	N	F	0	6.5													0	0
11-12-80	N	F	0	6.5													0	0
4-08-80	D	C	0	4.0													0	0
4-08-80	D	C	2	4.0													0	0
4-08-80	D	C	4	4.0													0	0
4-08-80	D	C	6	4.0													0	0
4-17-80	N	C	0	6.7													0	0
4-17-80	N	C	2	6.3													0	0
4-17-80	N	C	4	6.3													0	0
4-17-80	N	C	6	5.7													0	0
4-08-80	D	D	0	3.0													0	0
4-08-80	D	D	2	3.5													0	0
4-08-80	D	D	4	3.5													0	0
4-08-80	D	D	6	3.5													0	0
4-08-80	D	D	8	3.5													0	0
4-17-80	N	D	0	5.9											31		31	0
4-17-80	N	D	2	5.6													0	0
4-17-80	N	D	4	5.6													0	0
4-17-80	N	D	6	5.6													0	0
4-17-80	N	D	8	5.6													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-08-80	D	E	0	2.0													0	0
4-08-80	D	E	8	2.0													0	0
4-08-80	D	E	14	2.0													0	0
4-08-80	D	E	20	2.0													0	0
4-17-80	N	E	0	3.2													0	0
4-17-80	N	E	8	3.2													0	0
4-17-80	N	E	14	3.2													0	0
4-17-80	N	E	20	3.2													0	0
4-08-80	D	G	0	3.0													0	0
4-08-80	D	G	2	3.0													0	0
4-08-80	D	G	4	3.0													0	0
4-08-80	D	G	6	3.5													0	0
4-16-80	N	G	0	7.5													0	0
4-16-80	N	G	2	6.5													0	0
4-16-80	N	G	4	6.5													0	0
4-16-80	N	G	6	6.0													0	0
4-08-80	D	H	0	3.0													0	0
4-08-80	D	H	2	3.0													0	0
4-08-80	D	H	4	3.0													0	0
4-08-80	D	H	6	3.0													0	0
4-08-80	D	H	8	3.0													0	0
4-16-80	N	H	0	6.2													0	0
4-16-80	N	H	2	5.1													0	0
4-16-80	N	H	4	5.1													0	0
4-16-80	N	H	6	5.1													0	0
4-16-80	N	H	8	5.1													0	0
4-08-80	D	R	0	3.5													0	0
4-08-80	D	R	2	3.5													0	0
4-08-80	D	R	4	3.5													0	0
4-08-80	D	R	6	3.5													0	0
4-17-80	N	R	0	5.6													0	0
4-17-80	N	R	2	5.6													0	0
4-17-80	N	R	4	5.6													0	0
4-17-80	N	R	6	5.6													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-08-80	D	W	0	2.5													0	0
4-08-80	D	W	8	2.5													0	0
4-08-80	D	W	14	2.5													0	0
4-08-80	D	W	20	2.5													0	0
4-16-80	N	W	0	3.9													0	0
4-16-80	N	W	8	3.4													0	0
4-16-80	N	W	14	3.4													0	0
4-17-80	N	W	20	3.2													0	0
5-13-80	D	C	0	14.0													0	0
5-13-80	D	C	2	13.0			24									XP: 48	72	0
5-13-80	D	C	4	13.0			29										29	0
5-13-80	D	C	6	12.8			116										116	0
5-15-80	N	C	0	14.0			87									QL: 29	116	0
5-15-80	N	C	2	13.0			187										187	0
5-15-80	N	C	4	13.0			97										97	0
5-15-80	N	C	6	11.0			277										277	0
5-13-80	D	D	0	13.5													0	0
5-13-80	D	D	2	12.0													0	0
5-13-80	D	D	4	12.0			133										133	0
5-13-80	D	D	6	12.0			36										36	0
5-13-80	D	D	8	12.0													0	0
5-15-80	N	D	0	13.0			174										174	0
5-15-80	N	D	2	14.5			23										23	0
5-15-80	N	D	4	14.5			210										210	0
5-14-80	N	D	6	14.5			126										126	0
5-14-80	N	D	8	10.5			156										156	0
5-14-80	D	E	0	11.0													0	0
5-14-80	D	E	8	10.0													0	0
5-14-80	D	E	14	10.0													0	0
5-14-80	D	E	20	9.5													0	0
5-14-80	N	E	0	11.1													0	0
5-14-80	N	E	8	9.5													0	0
5-14-80	N	E	14	9.5													0	0
5-14-80	N	E	20	8.9													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
5-13-80	D	G	0	13.2			19										19	0
5-13-80	D	G	2	12.5													0	0
5-13-80	D	G	4	12.5													0	0
5-13-80	D	G	6	12.5			18										18	0
5-14-80	N	G	0	14.0			78										78	0
5-14-80	N	G	2	12.0			72										72	0
5-14-80	N	G	4	12.0			108										108	0
5-14-80	N	G	6	11.0			62										62	0
5-13-80	D	H	0	12.5													0	0
5-13-80	D	H	2	11.5													0	0
5-13-80	D	H	4	11.5													0	0
5-13-80	D	H	6	11.5													0	0
5-13-80	D	H	8	11.5													0	0
5-14-80	N	H	0	13.5			133										133	0
5-14-80	N	H	2	11.5			66										66	0
5-14-80	N	H	4	11.5			49										49	0
5-14-80	N	H	6	11.5			56										56	0
5-14-80	N	H	8	11.0			47										47	0
5-13-80	D	R	0	10.2			13										13	0
5-13-80	D	R	2	10.2													0	0
5-13-80	D	R	4	10.2													0	0
5-13-80	D	R	6	9.0			69										69	0
5-15-80	N	R	0	12.5			594										594	0
5-15-80	N	R	2	11.5			704										704	0
5-15-80	N	R	4	11.5			602										602	0
5-15-80	N	R	6	11.0			330										330	0
5-13-80	D	W	0	16.0													0	0
5-13-80	D	W	8	15.0													0	0
5-13-80	D	W	14	15.0													0	0
5-13-80	D	W	20	15.0													0	0
5-14-80	N	W	0	10.5													0	0
5-14-80	N	W	8	8.7											21		21	0
5-14-80	N	W	14	8.7													0	0
5-14-80	N	W	20	8.2													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	DI	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-11-80	D	C	0	16.8													0	0
6-11-80	D	C	2	15.5	25												25	0
6-11-80	D	C	4	15.5		25		25									50	0
6-11-80	D	C	6	15.0				56									56	0
6-11-80	N	C	0	14.5				79			79						158	0
6-11-80	N	C	2	13.5													0	0
6-11-80	N	C	4	13.5		179	85	85								XP: 85	434	807
6-11-80	N	C	6	13.2													0	523
6-11-80	D	D	0	17.7													0	0
6-11-80	D	D	2	16.8													0	0
6-11-80	D	D	4	16.8													0	0
6-11-80	D	D	6	16.8				21									21	0
6-11-80	D	D	8	16.8				18									18	0
6-11-80	N	D	0	14.9													0	1506
6-11-80	N	D	2	13.8													0	12842
6-11-80	N	D	4	13.8													0	952
6-11-80	N	D	6	13.8													0	27992
6-11-80	N	D	8	11.9													0	10614
6-11-80	D	E	0	16.1													0	0
6-11-80	D	E	8	12.2													0	0
6-11-80	D	E	14	12.2			15										15	0
6-11-80	D	E	20	11.8													0	0
6-11-80	N	E	0	14.1			31	63									94	0
6-11-80	N	E	8	11.4				27									27	0
6-11-80	N	E	14	11.4			34										34	0
6-11-80	N	E	20	11.1			29										29	0
6-11-80	D	G	0	16.0		17											17	0
6-11-80	D	G	2	15.9				17									17	0
6-11-80	D	G	4	15.9													0	0
6-11-80	D	G	6	16.0												XP: 16	16	0
6-10-80	N	G	0	14.0				120									120	0
6-10-80	N	G	2	12.8	40												40	41
6-10-80	N	G	4	12.8			39										39	0
6-10-80	N	G	6	12.8								56					56	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-11-80	D	H	0	18.7													0	20
6-11-80	D	H	2	14.9													0	0
6-11-80	D	H	4	14.9	20			20									40	0
6-11-80	D	H	6	14.9				19									19	0
6-11-80	D	H	8	14.2				32									32	0
6-10-80	N	H	0	14.1													0	0
6-10-80	N	H	2	12.8									28				28	0
6-10-80	N	H	4	12.8			28										28	0
6-10-80	N	H	6	12.8									29				29	0
6-10-80	N	H	8	12.8													0	0
6-11-80	D	R	0	17.0													0	0
6-11-80	D	R	2	15.8				22									22	0
6-11-80	D	R	4	15.8				27									27	27
6-11-80	D	R	6	15.5													0	376
6-11-80	N	R	0	14.3													0	3918
6-11-80	N	R	2	13.0													0	4205
6-11-80	N	R	4	13.0				67									67	4078
6-11-80	N	R	6	12.8													0	0
6-11-80	D	W	0	15.1													0	0
6-11-80	D	W	8	13.0			16										16	0
6-11-80	D	W	14	13.0													0	0
6-11-80	D	W	20	12.0													0	0
6-11-80	N	W	0	13.6			93										93	0
6-11-80	N	W	8	11.6													0	0
6-11-80	N	W	14	11.6			28										28	0
6-11-80	N	W	20	11.5													0	0
7-08-80	D	C	0	19.9	126												126	0
7-08-80	D	C	2	19.7	3802												3802	0
7-08-80	D	C	4	19.7	1241			16									1257	0
7-08-80	D	C	6	19.3	1391												1391	0
7-09-80	N	C	0	14.4	856												856	0
7-09-80	N	C	2	18.9	501	33											534	0
7-09-80	N	C	4	18.9	1389	106											1495	1255
7-09-80	N	C	6	18.9	343	38											381	2074

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
7-08-80	D	D	0	19.2	42												42	0
7-08-80	D	D	2	18.8	4316												4316	0
7-08-80	D	D	4	18.8	628			18									646	0
7-08-80	D	D	6	18.8	376												376	0
7-08-80	D	D	8	18.5	255												255	0
7-09-80	N	D	0	19.5	1032												1032	0
7-09-80	N	D	2	18.0	1865												1865	0
7-09-80	N	D	4	18.0	324												324	0
7-09-80	N	D	6	18.0	224												224	0
7-09-80	N	D	8	17.5	448												448	0
7-08-80	D	E	0	18.5	15												15	0
7-08-80	D	E	8	15.0	1112		28	87								XP: 14	1241	0
7-08-80	D	E	14	15.0	195												195	0
7-08-80	D	E	20	10.5	622			17									639	0
7-09-80	N	E	0	18.7	675			135								XP: 27	837	0
7-08-80	N	E	8	18.5	62												62	0
7-08-80	N	E	13	18.5				36									36	0
7-08-80	N	E	20	16.0	102												102	0
7-08-80	D	G	0	20.2	65												65	0
7-08-80	D	G	2	20.1	2032	34											2066	0
7-08-80	D	G	4	20.2	1175												1175	0
7-08-80	D	G	6	20.0	464	16											480	0
7-08-80	N	G	0	20.0	519												519	0
7-08-80	N	G	2	19.5	618												618	0
7-08-80	N	G	4	19.5	350	50											400	0
7-08-80	N	G	6	19.0	135		27										162	0
7-08-80	D	H	0	19.4	52												52	0
7-08-80	D	H	2	19.0	266												266	0
7-08-80	D	H	4	19.0	127												127	0
7-08-80	D	H	6	19.0	196												196	0
7-08-80	D	H	8	19.0	525	16											541	0
7-08-80	N	H	0	19.5	573			55									628	0
7-08-80	N	H	2	19.5	256												256	0
7-08-80	N	H	4	19.5	164		54										218	0
7-08-80	N	H	6	19.5	78												78	0
7-08-80	N	H	8	19.0													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	DI	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
7-08-80	D	R	0	19.7	204												204	0
7-08-80	D	R	2	19.0	2249												2249	0
7-08-80	D	R	4	19.0	1474			21									1495	0
7-08-80	D	R	6	19.0	1305	22											1327	0
7-09-80	N	R	0	19.5	1946												1946	9292
7-09-80	N	R	2	18.5	1909	68		34									2011	5099
7-09-80	N	R	4	18.5	721	68				34							823	694
7-09-80	N	R	6	18.5	912	38											950	0
7-08-80	D	W	0	18.6													0	0
7-08-80	D	W	8	16.0	325			36									361	0
7-08-80	D	W	14	16.0	193												193	0
7-08-80	D	W	20	11.0	48												48	0
7-08-80	N	W	0	19.0	1164	34		654									1852	0
7-08-80	N	W	8	18.0	323			31									354	0
7-08-80	N	W	14	18.0	180	36		34									250	0
7-08-80	N	W	20	16.0	410			36									446	0
8-12-80	D	C	0	22.2	30												30	0
8-12-80	D	C	2	20.2	54												54	0
8-12-80	D	C	4	20.2	28												28	0
8-12-80	D	C	6	18.0	42												42	0
8-12-80	N	C	0	23.0	260												260	0
8-12-80	N	C	2	18.5	156												156	0
8-12-80	N	C	4	18.5	41												41	0
8-12-80	N	C	6	17.8					39								39	0
8-12-80	D	D	0	23.0	17												17	0
8-12-80	D	D	2	16.5													0	0
8-12-80	D	D	4	16.5	28												28	0
8-12-80	D	D	6	16.5	36												36	0
8-12-80	D	D	8	13.5	13												13	0
8-12-80	N	D	0	24.5	148												148	0
8-12-80	N	D	2	13.5	536												536	0
8-12-80	N	D	4	13.5						40							40	0
8-12-80	N	D	6	13.5													0	0
8-12-80	N	D	8	11.0	70												70	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
8-12-80	D	E	0	22.5	16												16	0
8-12-80	D	E	8	19.0													0	0
8-12-80	D	E	14	19.0													0	0
8-12-80	D	E	20	7.2													0	0
8-13-80	N	E	0	22.5	39												39	0
8-13-80	N	E	8	22.5													0	0
8-13-80	N	E	14	22.5													0	0
8-13-80	N	E	20	8.5													0	0
8-12-80	D	G	0	23.6	49												49	0
8-12-80	D	G	2	22.6	91												91	0
8-12-80	D	G	4	22.6	42												42	0
8-12-80	D	G	6	20.9	65												65	0
8-13-80	N	G	0	22.6	29												29	0
8-13-80	N	G	2	22.0	225												225	0
8-13-80	N	G	4	22.0						32							32	0
8-13-80	N	G	6	15.6													0	0
8-12-80	D	H	0	23.0													0	0
8-12-80	D	H	2	17.5	119												119	0
8-12-80	D	H	4	17.5													0	0
8-12-80	D	H	6	17.5	14												14	0
8-12-80	D	H	8	15.0													0	0
8-13-80	N	H	0	23.0	64												64	0
8-13-80	N	H	2	13.5	72												72	0
8-13-80	N	H	4	13.5	32												32	0
8-13-80	N	H	6	13.5													0	0
8-13-80	N	H	8	13.0													0	0
8-12-80	D	R	0	22.5	149												149	0
8-12-80	D	R	2	22.0	103												103	0
8-12-80	D	R	4	22.0	78												78	0
8-12-80	D	R	6	20.0	180												180	0
8-12-80	N	R	0	22.5	169												169	0
8-12-80	N	R	2	22.0	333												333	0
8-12-80	N	R	4	22.0	41												41	0
8-12-80	N	R	6	14.5													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
8-12-80	D	W	0	22.8													0	0
8-12-80	D	W	8	21.4													0	0
8-12-80	D	W	14	21.4													0	0
8-12-80	D	W	20	7.3													0	0
8-13-80	N	W	0	22.5	29												29	0
8-13-80	N	W	8	22.5	33												33	0
8-13-80	N	W	14	22.5													0	0
8-13-80	N	W	20	8.6													0	0
9-10-80	D	C	0	19.5													0	0
9-10-80	D	C	2	16.0													0	0
9-10-80	D	C	4	16.0													0	0
9-10-80	D	C	6	13.4													0	0
9-09-80	N	C	0	21.1	130												130	0
9-09-80	N	C	2	20.0													0	0
9-09-80	N	C	4	20.0													0	0
9-09-80	N	C	6	10.0													0	0
9-10-80	D	D	0	17.5													0	0
9-10-80	D	D	2	11.5													0	0
9-10-80	D	D	4	11.5													0	0
9-10-80	D	D	6	11.5													0	0
9-10-80	D	D	8	9.0													0	0
9-09-80	N	D	0	21.1	97												97	0
9-09-80	N	D	2	20.0													0	0
9-09-80	N	D	4	20.0	24												24	0
9-09-80	N	D	6	20.0													0	0
9-09-80	N	D	8	7.2	123												123	0
9-10-80	D	E	0	17.5													0	0
9-10-80	D	E	8	6.8													0	0
9-10-80	D	E	14	6.8													0	0
9-10-80	D	E	20	5.5													0	0
9-09-80	N	E	0	22.2													0	0
9-09-80	N	E	8	15.6													0	0
9-08-80	N	E	14	15.6													0	0
9-08-80	N	E	20	5.6													0	0

Appendix 4. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
9-10-80	D	G	0	15.9	32												32	0
9-10-80	D	G	2	13.7													0	0
9-10-80	D	G	4	13.7													0	0
9-10-80	D	G	6	11.0													0	0
9-08-80	N	G	0	20.6	27												27	0
9-08-80	N	G	2	20.0	124												124	0
9-08-80	N	G	4	20.0													0	0
9-08-80	N	G	6	9.5													0	0
9-10-80	D	H	0	14.5													0	0
9-10-80	D	H	2	9.1	15												15	0
9-10-80	D	H	4	9.1													0	0
9-10-80	D	H	6	9.1													0	0
9-10-80	D	H	8	8.0													0	0
9-08-80	N	H	0	21.1	28												28	0
9-08-80	N	H	2	16.7													0	0
9-08-80	N	H	4	16.7													0	0
9-08-80	N	H	6	16.7													0	0
9-08-80	N	H	8	7.2													0	0
9-10-80	D	R	0	20.0													0	0
9-10-80	D	R	2	18.5	14												14	0
9-10-80	D	R	4	18.5													0	0
9-10-80	D	R	6	14.1													0	0
9-09-80	N	R	0	21.1													0	0
9-09-80	N	R	2	20.0													0	0
9-09-80	N	R	4	20.0	23												23	0
9-09-80	N	R	6	11.1													0	0
9-10-80	D	W	0	19.5													0	0
9-10-80	D	W	8	11.1													0	0
9-10-80	D	W	14	11.1													0	0
9-10-80	D	W	20	6.0													0	0
9-08-80	N	W	0	22.2													0	0
9-08-80	N	W	8	20.6													0	0
9-08-80	N	W	14	20.6													0	0
9-08-80	N	W	20	5.6													0	0

Appendix 5. Densities (no./1000 m^3) for fish eggs and larvae collected at beach (A, B, F) and open water (C, D, G, H, E, W, R) stations in Cook Plant study areas, southeastern Lake Michigan, 1981. See Fig. 1 for station locations. Date = month, day, year; Dl = diel period, D = day, N = night; Sta = station; Dpt = depth in meters, O = surface tow. See Table 12 for species corresponding to species codes.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-06-81	D	A	O	10.5													0	0
4-06-81	D	A	O	10.5													0	0
4-06-81	N	A	O	9.4													0	0
4-06-81	N	A	O	9.4													0	0
4-06-81	D	B	O	10.5													0	0
4-06-81	D	B	O	10.5													0	246
4-06-81	N	B	O	9.0													0	0
4-06-81	N	B	O	9.0													0	125
4-06-81	D	F	O	10.4													0	0
4-06-81	D	F	O	10.4													0	0
4-06-81	N	F	O	9.4													0	0
4-06-81	N	F	O	9.4													0	0
5-14-81	D	A	O	10.3													0	0
5-14-81	D	A	O	10.3													0	0
5-14-81	N	A	O	9.0													0	0
5-14-81	N	A	O	9.0			106					106					212	0
5-14-81	D	B	O	8.8				87									87	0
5-14-81	D	B	O	8.8													0	0
5-14-81	N	B	O	9.5													0	0
5-14-81	N	B	O	9.5													0	0
5-14-81	D	F	O	9.4				125									125	0
5-14-81	D	F	O	9.4				125									125	0
5-14-81	N	F	O	8.8													0	0
5-14-81	N	F	O	8.8													0	0
6-08-81	D	A	O	19.0	367	244											611	20833
6-08-81	D	A	O	18.0	229	228										XP: 229	686	27586
6-09-81	N	A	O	17.5	307	2149										XM: 307	2763	0
6-09-81	N	A	O	17.5		1108											1108	316

Appendix 5. Continued.

Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-08-81	D	B	0	17.5	191	191											382	0
6-08-81	D	B	0	17.5													0	0
6-08-81	N	B	0	18.0		1998											1998	0
6-08-81	N	B	0	18.0		954											954	0
6-08-81	D	F	0	18.5													0	0
6-08-81	D	F	0	18.5													0	157
6-08-81	N	F	0	18.0													0	0
6-08-81	N	F	0	18.0													0	0
7-08-81	D	A	0	24.5	202											XP: 202	404	1013
7-08-81	D	A	0	24.5													0	0
7-09-81	N	A	0	24.2	1386	1731										XP: 115	3232	115
7-09-81	N	A	0	24.2	587	704										ES: 353	1644	353
7-08-81	D	B	0	24.6													0	318
7-08-81	D	B	0	24.6	808												808	0
7-08-81	N	B	0	24.5	378	526										ES: 151	1055	1363
7-08-81	N	B	0	24.5	1473	184										XP: 368	2025	1659
7-08-81	D	F	0	23.0	221												221	0
7-08-81	D	F	0	23.0	354												354	177
7-08-81	N	F	0	24.0	430	429										XP: 107	966	0
7-08-81	N	F	0	24.0	124	124											248	0
8-10-81	D	A	0	24.8	2984												2984	0
8-10-81	D	A	0	25.2	1952												1952	0
8-10-81	N	A	0	23.7	258	1383											1641	0
8-10-81	N	A	0	23.7	480	961											1441	0
8-10-81	D	B	0	23.7	309												309	0
8-10-81	D	B	0	23.7	246												246	0
8-10-81	N	B	0	22.6	115	345											460	0
8-10-81	N	B	0	22.6	118	590											708	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
8-10-81	D	F	0	23.5	380												380	0
8-10-81	D	F	0	23.5	235												235	0
8-10-81	N	F	0	23.0	140	280											420	140
8-10-81	N	F	0	23.0	146	292											438	0
9-15-81	D	A	0	22.0	258												258	0
9-15-81	D	A	0	22.0	120												120	0
9-15-81	N	A	0	20.2													0	0
9-15-81	N	A	0	20.2													0	0
9-15-81	D	B	0	21.8	911												911	0
9-15-81	D	B	0	21.8	1734												1734	0
9-15-81	N	B	0	21.7													0	0
9-15-81	N	B	0	21.7	136												136	0
9-15-81	D	F	0	20.7													0	0
9-15-81	D	F	0	20.7													0	0
9-15-81	N	F	0	20.4	196												196	0
9-15-81	N	F	0	20.4	320												320	0
10-12-81	D	A	0	13.8													0	0
10-12-81	D	A	0	13.8													0	0
10-12-81	N	A	0	13.5													0	0
10-12-81	N	A	0	13.5													0	0
10-12-81	D	B	0	13.9													0	0
10-12-81	D	B	0	13.9													0	0
10-12-81	N	B	0	12.5													0	0
10-12-81	N	B	0	12.5													0	0
10-12-81	D	F	0	13.3													0	0
10-12-81	D	F	0	13.3													0	0
10-12-81	N	F	0	13.0													0	0
10-12-81	N	F	0	13.0													0	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
11-09-81	D	A	0	7.5													0	0
11-09-81	D	A	0	7.5													0	0
11-09-81	N	A	0	7.8													0	0
11-09-81	N	A	0	7.8													0	0
11-09-81	D	B	0	8.7													0	0
11-09-81	D	B	0	8.7													0	0
11-09-81	N	B	0	7.8													0	0
11-09-81	N	B	0	7.8													0	0
11-09-81	D	F	0	9.5													0	0
11-09-81	D	F	0	9.5													0	0
11-09-81	N	F	0	8.5													0	0
11-09-81	N	F	0	8.5													0	0
4-08-81	D	C	0	7.0													0	0
4-08-81	D	C	2	7.0													0	0
4-08-81	D	C	4	7.0													0	0
4-08-81	D	C	6	7.0													0	0
4-15-81	N	C	0	7.8													0	0
4-15-81	N	C	2	7.2													0	0
4-15-81	N	C	4	7.2													0	0
4-15-81	N	C	6	7.0													0	0
4-08-81	D	D	0	6.7													0	0
4-08-81	D	D	2	6.7													0	0
4-08-81	D	D	4	6.7													0	0
4-08-81	D	D	6	6.7													0	0
4-08-81	D	D	8	6.8													0	0
4-15-81	N	D	0	8.0													0	0
4-15-81	N	D	2	7.5													0	0
4-15-81	N	D	4	7.5													0	0
4-15-81	N	D	6	7.5													0	0
4-15-81	N	D	8	7.0													0	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-08-81	D	E	0	4.7													0	0
4-08-81	D	E	8	4.7													0	0
4-08-81	D	E	14	4.7													0	0
4-08-81	D	E	20	4.7													0	0
4-15-81	N	E	0	5.1													0	0
4-15-81	N	E	8	4.9											23		23	0
4-15-81	N	E	14	4.9													0	0
4-15-81	N	E	20	4.8													0	0
4-08-81	D	G	0	7.0													0	0
4-08-81	D	G	2	7.0													0	0
4-08-81	D	G	4	7.0													0	0
4-08-81	D	G	6	7.0													0	0
4-16-81	N	G	0	7.6													0	0
4-16-81	N	G	2	7.4													0	0
4-16-81	N	G	4	7.4													0	0
4-16-81	N	G	6	6.9													0	0
4-08-81	D	H	0	6.5													0	0
4-08-81	D	H	2	6.5													0	0
4-08-81	D	H	4	6.5													0	0
4-08-81	D	H	6	6.5											17		17	0
4-08-81	D	H	8	6.5													0	0
4-16-81	N	H	0	7.6													0	0
4-16-81	N	H	2	7.0													0	0
4-16-81	N	H	4	7.0													0	0
4-16-81	N	H	6	7.0													0	0
4-16-81	N	H	8	6.7													0	33
4-08-81	D	R	0	7.0													0	0
4-08-81	D	R	2	7.0													0	0
4-08-81	D	R	4	7.0													0	0
4-08-81	D	R	6	7.0													0	0
4-15-81	N	R	0	10.7													0	0
4-15-81	N	R	2	10.7													0	0
4-15-81	N	R	4	10.7													0	0
4-15-81	N	R	6	10.5													0	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-08-81	D	W	0	3.3													0	0
4-08-81	D	W	8	3.3													0	0
4-08-81	D	W	14	3.3													0	0
4-08-81	D	W	20	3.2													0	0
4-16-81	N	W	0	4.7													0	0
4-16-81	N	W	8	4.7													0	0
4-16-81	N	W	14	4.7													0	0
4-16-81	N	W	20	4.7											27		27	0
5-13-81	D	C	0	9.5			17										17	0
5-13-81	D	C	2	8.5			38										38	0
5-13-81	D	C	4	8.5			39										39	0
5-13-81	D	C	6	8.5			48										48	0
5-12-81	N	C	0	8.6		27	54										81	0
5-12-81	N	C	2	8.5			29										29	0
5-12-81	N	C	4	8.5			98										98	0
5-13-81	N	C	6	7.9													0	0
5-13-81	D	D	0	10.1			18										18	0
5-13-81	D	D	2	7.7													0	0
5-13-81	D	D	4	7.7													0	0
5-13-81	D	D	6	7.7			54										54	0
5-13-81	D	D	8	7.2			26										26	0
5-12-81	N	D	0	8.7													0	0
5-12-81	N	D	2	7.7	39												39	0
5-12-81	N	D	4	7.7													0	0
5-12-81	N	D	6	7.7													0	0
5-12-81	N	D	8	7.7			66										66	0
5-13-81	D	E	0	9.0													0	0
5-13-81	D	E	8	9.0													0	0
5-13-81	D	E	14	9.0													0	0
5-13-81	D	E	20	8.5													0	0
5-12-81	N	E	0	8.5								25					25	0
5-12-81	N	E	8	8.1													0	0
5-12-81	N	E	14	8.1													0	0
5-12-81	N	E	20	7.5								26					26	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
5-13-81	D	G	0	10.5													0	0
5-13-81	D	G	2	9.1													0	0
5-13-81	D	G	4	9.1													0	0
5-13-81	D	G	6	9.5													0	0
5-12-81	N	G	0	9.0			64										64	0
5-12-81	N	G	2	9.0													0	0
5-12-81	N	G	4	9.0													0	0
5-12-81	N	G	6	8.4			37										37	0
5-13-81	D	H	0	10.4													0	0
5-13-81	D	H	2	9.0													0	0
5-13-81	D	H	4	9.0													0	0
5-13-81	D	H	6	9.0								20					20	0
5-13-81	D	H	8	9.0			37										37	0
5-12-81	N	H	0	8.9		27											27	0
5-12-81	N	H	2	8.4			35										35	0
5-12-81	N	H	4	8.4			38										38	0
5-12-81	N	H	6	8.4													0	0
5-12-81	N	H	8	8.4			49										49	0
5-13-81	D	R	0	11.8			75										75	0
5-13-81	D	R	2	10.0													0	0
5-13-81	D	R	4	10.0			40										40	0
5-13-81	D	R	6	10.0													0	0
5-13-81	N	R	0	8.8			94										94	0
5-13-81	N	R	2	8.2		62	124										186	0
5-13-81	N	R	4	8.2			322	39									361	0
5-13-81	N	R	6	8.0			68										68	0
5-13-81	D	W	0	9.5													0	0
5-13-81	D	W	8	9.0													0	0
5-13-81	D	W	14	9.0													0	0
5-13-81	D	W	20	8.5													0	0
5-12-81	N	W	0	8.0													0	0
5-12-81	N	W	8	7.8													0	0
5-12-81	N	W	14	7.8			62										62	0
5-12-81	N	W	20	7.5													0	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-09-81	D	C	0	18.0			18										18	0
6-09-81	D	C	2	18.0	17												17	0
6-09-81	D	C	4	18.0	19		9	9									37	0
6-09-81	D	C	6	18.0			18	18									36	0
6-10-81	N	C	0	18.6	61	60											121	0
6-10-81	N	C	2	17.6	64												64	0
6-10-81	N	C	4	17.6	92	414	45										551	0
6-10-81	N	C	6	17.0		100											100	0
6-09-81	D	D	0	18.0													0	0
6-09-81	D	D	2	17.8													0	0
6-09-81	D	D	4	17.8			40										40	0
6-09-81	D	D	6	17.8													0	0
6-09-81	D	D	8	17.2													0	0
6-10-81	N	D	0	19.0													0	0
6-10-81	N	D	2	17.0	33												33	0
6-10-81	N	D	4	17.0													0	0
6-10-81	N	D	6	17.0		115											115	0
6-10-81	N	D	8	16.6	25			24								UC: 24	73	0
6-09-81	D	E	0	16.5													0	0
6-09-81	D	E	8	16.2													0	0
6-09-81	D	E	14	16.2													0	0
6-09-81	D	E	20	6.5													0	59
6-10-81	N	E	0	18.0				67									67	0
6-11-81	N	E	8	16.5													0	0
6-11-81	N	E	14	16.5			41										41	0
6-11-81	N	E	20	15.5													0	0
6-09-81	D	G	0	18.5	34												34	0
6-09-81	D	G	2	18.0	24			24									48	0
6-09-81	D	G	4	18.0			24										24	0
6-09-81	D	G	6	18.0													0	0
6-11-81	N	G	0	16.8			22									XP: 22	44	0
6-11-81	N	G	2	16.6		25			25								50	5724
6-11-81	N	G	4	16.6	25	25		25									75	467
6-11-81	N	G	6	16.2	23		46										69	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	D1	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-09-81	D	H	0	18.0	18			36								XP: 18	72	0
6-09-81	D	H	2	17.5				19									19	0
6-09-81	D	H	4	17.5	20		20										40	0
6-09-81	D	H	6	17.5	36												36	0
6-09-81	D	H	8	17.2													0	0
6-11-81	N	H	0	18.0	145			36								XP: 36	217	0
6-11-81	N	H	2	16.8	40		20										60	0
6-11-81	N	H	4	16.8	85		42										127	0
6-11-81	N	H	6	16.8			40										40	0
6-11-81	N	H	8	16.5													0	0
6-09-81	D	R	0	19.0												XP: 19	19	0
6-09-81	D	R	2	19.0	32			16								XP: 16	64	0
6-09-81	D	R	4	19.0	44		66	88									198	0
6-09-81	D	R	6	19.0	50			25									75	0
6-10-81	N	R	0	18.5	344												344	31
6-10-81	N	R	2	17.8	2038			27		27							2092	0
6-10-81	N	R	4	17.8	8913	31	31										8975	95
6-10-81	N	R	6	16.8													0	34
6-09-81	D	W	0	17.5													0	0
6-09-81	D	W	8	16.0			19										19	0
6-09-81	D	W	14	16.0			59										59	0
6-09-81	D	W	20	9.0													0	0
6-11-81	N	W	0	17.0													0	0
6-11-81	N	W	8	16.0			24										24	0
6-11-81	N	W	14	16.0													0	0
6-11-81	N	W	20	6.6													0	2063
7-07-81	D	C	0	20.8													0	0
7-07-81	D	C	2	15.5													0	0
7-07-81	D	C	4	15.5	131			16									147	0
7-07-81	D	C	6	14.6													0	0
7-06-81	N	C	0	19.5													0	0
7-06-81	N	C	2	14.0	49												49	0
7-06-81	N	C	4	14.0	342												342	0
7-06-81	N	C	6	13.0													0	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
7-07-81	D	D	0	23.0													0	0
7-07-81	D	D	2	18.0													0	0
7-07-81	D	D	4	18.0													0	0
7-07-81	D	D	6	18.0	70												70	0
7-07-81	D	D	8	13.5													0	0
7-06-81	N	D	0	19.4	90												90	0
7-06-81	N	D	2	15.0													0	0
7-06-81	N	D	4	15.0													0	0
7-06-81	N	D	6	15.0	644												644	0
7-06-81	N	D	8	12.2	156												156	0
7-07-81	D	E	0	21.0													0	0
7-07-81	D	E	8	5.0													0	0
7-07-81	D	E	14	5.0													0	0
7-07-81	D	E	20	5.0													0	0
7-07-81	N	E	0	21.4													0	0
7-07-81	N	E	8	14.5													0	0
7-07-81	N	E	14	14.5													0	0
7-06-81	N	E	20	7.5													0	0
7-07-81	D	G	0	21.0													0	0
7-07-81	D	G	2	19.5	14												14	0
7-07-81	D	G	4	19.5													0	0
7-07-81	D	G	6	14.7													0	0
7-07-81	N	G	0	20.5													0	0
7-07-81	N	G	2	15.5													0	0
7-07-81	N	G	4	15.5	174												174	0
7-07-81	N	G	6	14.0	242												242	0
7-07-81	D	H	0	23.5													0	0
7-07-81	D	H	2	17.8													0	0
7-07-81	D	H	4	17.8	50												50	0
7-07-81	D	H	6	17.8													0	0
7-07-81	D	H	8	12.5													0	0
7-07-81	N	H	0	20.2	60												60	0
7-07-81	N	H	2	15.0													0	0
7-07-81	N	H	4	15.0													0	0
7-07-81	N	H	6	15.0													0	0
7-07-81	N	H	8	13.6													0	0

Appendix 5. Continued.

Sample Parameters					Species/Groups														
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.		Total Larvae	Eggs
7-07-81	D	R	0	21.0														0	0
7-07-81	D	R	2	18.8	13													13	0
7-07-81	D	R	4	18.8	140													140	0
7-07-81	D	R	6	14.5														0	0
7-06-81	N	R	0	19.4														0	0
7-06-81	N	R	2	16.5														0	0
7-06-81	N	R	4	16.5														0	0
7-06-81	N	R	6	12.5														0	46
7-07-81	D	W	0	22.0														0	0
7-07-81	D	W	8	5.0														0	0
7-07-81	D	W	14	5.0														0	0
7-07-81	D	W	20	4.5														0	0
7-06-81	N	W	0	21.0	64													64	0
7-06-81	N	W	8	14.5														0	0
7-06-81	N	W	14	14.5														0	0
7-06-81	N	W	20	7.0														0	0
8-12-81	D	C	0	23.5														0	0
8-12-81	D	C	2	23.5	130													130	0
8-12-81	D	C	4	23.5	84													84	0
8-12-81	D	C	6	23.2	81	16												97	0
8-12-81	N	C	0	23.5	280													280	0
8-12-81	N	C	2	23.5	163	54												217	0
8-12-81	N	C	4	23.5	326													326	0
8-12-81	N	C	6	23.0	378	27										XP:	106	511	0
8-12-81	D	D	0	23.5												XP:	14	14	0
8-12-81	D	D	2	23.5	109													109	0
8-12-81	D	D	4	23.5	112													112	0
8-12-81	D	D	6	23.5	112													112	0
8-12-81	D	D	8	23.5	80													80	0
8-12-81	N	D	0	23.0	869													869	0
8-12-81	N	D	2	23.0	552													552	0
8-12-81	N	D	4	23.0	648													648	0
8-12-81	N	D	6	23.0	728				25							XP:	25	778	0
8-12-81	N	D	8	23.0	643											XP:	19	662	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
8-12-81	D	E	0	22.8													0	0
8-12-81	D	E	8	22.0													0	0
8-12-81	D	E	14	22.0													0	0
8-12-81	D	E	20	20.8													0	0
8-12-81	N	E	0	22.5	30												30	0
8-12-81	N	E	8	22.5													0	0
8-12-81	N	E	14	22.5	38												38	0
8-12-81	N	E	20	22.0	23												23	0
8-12-81	D	G	0	24.0	16											XP: 16	32	0
8-12-81	D	G	2	24.0	184												184	0
8-12-81	D	G	4	24.0	198												198	0
8-12-81	D	G	6	24.0	118												118	0
8-13-81	N	G	0	23.2	154												154	0
8-12-81	N	G	2	23.0	208												208	0
8-12-81	N	G	4	23.0	69												69	0
8-12-81	N	G	6	23.0	156	50											206	0
8-12-81	D	H	0	23.7													0	0
8-12-81	D	H	2	23.7	227												227	0
8-12-81	D	H	4	23.7	168											XP: 15	183	0
8-12-81	D	H	6	23.7	62												62	0
8-12-81	D	H	8	23.7	26												26	0
8-12-81	N	H	0	23.0	641											XP: 37	678	0
8-12-81	N	H	2	23.0	186												186	0
8-12-81	N	H	4	23.0	211												211	0
8-12-81	N	H	6	23.0	433												433	0
8-12-81	N	H	8	22.5	609												609	0
8-12-81	D	R	0	24.0	126												126	0
8-12-81	D	R	2	23.8	92											XP: 27	119	0
8-12-81	D	R	4	23.8	16												16	0
8-12-81	D	R	6	23.0	44	21											65	0
8-12-81	N	R	0	24.1	713	25											738	0
8-12-81	N	R	2	23.5	156												156	0
8-12-81	N	R	4	23.5	100												100	0
8-12-81	N	R	6	23.2	96												96	24

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
8-12-81	D	W	0	22.8													0	0
8-12-81	D	W	8	22.0	14												14	0
8-12-81	D	W	14	22.0	13												13	0
8-12-81	D	W	20	21.0													0	0
8-12-81	N	W	0	22.5													0	0
8-12-81	N	W	8	22.5	18												18	0
8-12-81	N	W	14	22.5													0	0
8-12-81	N	W	20	22.0													0	0
9-18-81	D	C	0	20.0													0	0
9-18-81	D	C	2	20.0	34												34	0
9-18-81	D	C	4	20.0													0	0
9-18-81	D	C	6	20.0													0	0
9-23-81	N	C	0	18.6													0	0
9-23-81	N	C	2	18.6													0	0
9-23-81	N	C	4	18.6													0	0
9-23-81	N	C	6	18.5													0	0
9-18-81	D	D	0	19.5													0	0
9-18-81	D	D	2	20.0	16												16	0
9-18-81	D	D	4	20.0													0	0
9-18-81	D	D	6	20.0													0	0
9-18-81	D	D	8	20.0													0	0
9-23-81	N	D	0	18.6													0	0
9-23-81	N	D	2	18.5													0	0
9-23-81	N	D	4	18.5													0	0
9-23-81	N	D	6	18.5													0	0
9-23-81	N	D	8	18.4													0	0
9-18-81	D	E	0	20.0													0	0
9-18-81	D	E	8	20.0													0	0
9-18-81	D	E	14	20.0													0	0
9-18-81	D	E	20	20.0													0	0
9-22-81	N	E	0	18.8													0	0
9-22-81	N	E	8	18.8													0	0
9-22-81	N	E	14	18.8													0	0
9-22-81	N	E	20	18.8													0	0

Appendix 5. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
9-18-81	D	G	0	20.3	55												55	0
9-18-81	D	G	2	20.3													0	0
9-18-81	D	G	4	20.3													0	0
9-18-81	D	G	6	19.7													0	0
9-22-81	N	G	0	19.4													0	0
9-22-81	N	G	2	19.4													0	0
9-22-81	N	G	4	19.4	30												30	0
9-22-81	N	G	6	19.2													0	0
9-18-81	D	H	0	20.2	18												18	0
9-18-81	D	H	2	20.0													0	0
9-18-81	D	H	4	20.0													0	0
9-18-81	D	H	6	20.0													0	0
9-18-81	D	H	8	19.5													0	0
9-22-81	N	H	0	19.3													0	0
9-22-81	N	H	2	19.2													0	0
9-22-81	N	H	4	19.2													0	0
9-22-81	N	H	6	19.2													0	0
9-22-81	N	H	8	19.4													0	0
9-18-81	D	R	0	19.5	447												447	0
9-18-81	D	R	2	19.0													0	0
9-18-81	D	R	4	19.0	30												30	0
9-18-81	D	R	6	18.8													0	0
9-23-81	N	R	0	18.6													0	0
9-23-81	N	R	2	18.5													0	0
9-23-81	N	R	4	18.5	30												30	0
9-23-81	N	R	6	18.5													0	0
9-18-81	D	W	0	20.0													0	0
9-18-81	D	W	8	20.0													0	0
9-18-81	D	W	14	20.0													0	0
9-18-81	D	W	20	20.0													0	0
9-22-81	N	W	0	18.8													0	0
9-22-81	N	W	8	18.8													0	0
9-22-81	N	W	14	18.8													0	0
9-22-81	N	W	20	18.8													0	0

Appendix 6. Densities (no./1000 m³) for fish eggs and larvae collected at beach (A, B, F) and open water (C, D, G, H, E, W, R) stations in Cook Plant study areas, southeastern Lake Michigan, 1982. See Fig. 1 for station locations. Date = month, day, year; Dl = diel period, D = day, N = night; Sta = station; Dpt = depth in meters, O = surface tow. See Table 12 for species corresponding to species codes.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-15-82	D	A	O	9.8													0	0
4-15-82	D	A	O	9.8													0	0
4-15-82	N	A	O	5.5													0	0
4-15-82	N	A	O	5.5													0	0
4-15-82	D	B	O	10.3													0	0
4-15-82	D	B	O	10.3													0	0
4-15-82	N	B	O	8.0													0	0
4-15-82	N	B	O	8.0													0	0
4-15-82	D	F	O	9.5													0	0
4-15-82	D	F	O	9.5													0	0
4-15-82	N	F	O	6.5								360					360	0
4-15-82	N	F	O	6.5													0	0
5-12-82	D	A	O	16.4													0	0
5-12-82	D	A	O	16.4													0	0
5-13-82	N	A	O	13.5													0	0
5-13-82	N	A	O	13.5													0	0
5-12-82	D	B	O	14.8			338										338	0
5-12-82	D	B	O	14.8			644										644	0
5-12-82	N	B	O	14.0			139										139	0
5-12-82	N	B	O	14.0													0	0
5-12-82	D	F	O	14.6													0	0
5-12-82	D	F	O	14.6			325					325					650	0
5-12-82	N	F	O	13.5			275										275	0
5-12-82	N	F	O	13.5													0	0
6-17-82	D	A	O	19.7	271			813									1084	1219
6-17-82	D	A	O	19.7	605			454									1059	0
6-16-82	N	A	O	15.9	1184	590		593								XP: 98	2465	4945
6-16-82	N	A	O	15.9	394	1579		98									2071	1384

Appendix 6. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-17-82	D	B	0	19.5	1266	252		253									1771	126
6-17-82	D	B	0	19.5	2051			603									2654	0
6-16-82	N	B	0	15.9	229	688		306		76						QL: 76	1375	844
6-16-82	N	B	0	15.9	305	458		613									1376	1843
6-17-82	D	F	0	19.4	561	112	112	112									897	0
6-17-82	D	F	0	19.4	1191												1191	0
6-16-82	N	F	0	15.9	418	333											751	923
6-16-82	N	F	0	15.9	585	249					83					XP: 167	1084	3190
7-19-82	D	A	0	25.2		125											125	0
7-19-82	D	A	0	25.2	2380						119						2499	119
7-19-82	N	A	0	24.2	1023	1637											2660	205
7-19-82	N	A	0	24.2	612	1224					204						2040	612
7-19-82	D	B	0	26.0	639												639	0
7-19-82	D	B	0	26.0	1146												1146	0
7-19-82	N	B	0	24.0	1371	1720					5632						8723	0
7-19-82	N	B	0	24.0	736	1055					2539						4330	0
7-19-82	D	F	0	25.2	31640	1120											32760	0
7-19-82	D	F	0	25.2	30330	727											31057	0
7-19-82	N	F	0	24.5	728	849										XP: 121	1698	0
7-19-82	N	F	0	24.5	484	847										XP: 121	1452	121
8-10-82	D	A	0	22.5													0	660
8-10-82	D	A	0	22.5	444												444	0
8-10-82	N	A	0	21.5													0	1212
8-10-82	N	A	0	21.5													0	673
8-10-82	D	B	0	22.5	61												61	0
8-10-82	D	B	0	22.5	68												68	0
8-10-82	N	B	0	21.0													0	0
8-10-82	N	B	0	21.0													0	0

Appendix 6. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
8-10-82	D	F	0	22.3	71												71	0
8-10-82	D	F	0	22.4	72												72	0
8-10-82	N	F	0	21.2	321												321	0
8-10-82	N	F	0	21.2													0	0
9-13-82	D	A	0	23.8													0	0
9-13-82	D	A	0	23.8													0	0
9-13-82	N	A	0	22.6													0	0
9-13-82	N	A	0	22.6													0	0
9-13-82	D	B	0	23.8													0	0
9-13-82	D	B	0	23.8													0	0
9-13-82	N	B	0	23.2													0	0
9-13-82	N	B	0	23.2													0	0
9-13-82	D	F	0	23.5													0	0
9-13-82	D	F	0	23.5													0	0
9-13-82	N	F	0	22.3													0	0
9-13-82	N	F	0	22.3													0	0
10-11-82	D	A	0	14.8													0	0
10-11-82	D	A	0	14.8													0	0
10-12-82	N	A	0	13.3													0	0
10-12-82	N	A	0	13.3													0	0
10-11-82	D	B	0	14.8													0	0
10-11-82	D	B	0	14.8													0	0
10-12-82	N	B	0	13.4													0	0
10-12-82	N	B	0	13.4													0	0
10-11-82	D	F	0	14.8													0	0
10-11-82	D	F	0	14.8													0	0
10-12-82	N	F	0	14.0													0	0
10-12-82	N	F	0	14.0													0	0

Appendix 6. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
11-10-82	D	A	0	14.8													0	0
11-10-82	D	A	0	14.8													0	0
11-09-82	N	A	0	12.1													0	0
11-09-82	N	A	0	12.1													0	0
11-10-82	D	B	0	10.5													0	0
11-10-82	D	B	0	10.5													0	0
11-09-82	N	B	0	9.3													0	0
11-09-82	N	B	0	9.3													0	0
11-10-82	D	F	0	10.5													0	0
11-10-82	D	F	0	10.5													0	0
11-09-82	N	F	0	9.1													0	0
11-09-82	N	F	0	9.1													0	0
4-14-82	D	C	0	7.0													0	0
4-14-82	D	C	2	5.0						27							27	0
4-14-82	D	C	4	5.0													0	0
4-14-82	D	C	6	5.0													0	0
4-14-82	N	C	0	6.0													0	0
4-14-82	N	C	2	6.0													0	0
4-14-82	N	C	4	6.0													0	0
4-14-82	N	C	6	6.0													0	0
4-14-82	D	D	0	6.2													0	0
4-14-82	D	D	2	5.1													0	0
4-14-82	D	D	4	5.1													0	0
4-14-82	D	D	6	5.1													0	0
4-14-82	D	D	8	5.0													0	0
4-14-82	N	D	0	6.7													0	0
4-14-82	N	D	2	5.8													0	0
4-14-82	N	D	4	5.8													0	0
4-14-82	N	D	6	5.8													0	0
4-14-82	N	D	8	5.5													0	0

Appendix 6. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-14-82	D	E	0	2.5													0	0
4-14-82	D	E	8	2.5													0	0
4-14-82	D	E	14	2.5													0	0
4-14-82	D	E	20	2.5													0	0
4-14-82	N	E	0	1.5													0	0
4-14-82	N	E	8	1.9													0	0
4-14-82	N	E	14	1.9													0	0
4-14-82	N	E	20	1.5													0	0
4-14-82	D	G	0	5.0													0	0
4-14-82	D	G	2	4.7							31						31	0
4-14-82	D	G	4	4.7													0	0
4-14-82	D	G	6	4.7													0	0
4-13-82	N	G	0	6.2													0	0
4-13-82	N	G	2	6.1								56					56	0
4-13-82	N	G	4	6.1													0	0
4-13-82	N	G	6	5.8													0	0
4-14-82	D	H	0	4.8													0	0
4-14-82	D	H	2	4.3													0	0
4-14-82	D	H	4	4.3													0	0
4-14-82	D	H	6	4.3													0	0
4-14-82	D	H	8	4.7													0	0
4-13-82	N	H	0	3.5													0	0
4-13-82	N	H	2	3.5													0	0
4-13-82	N	H	4	3.5													0	0
4-13-82	N	H	6	3.5													0	0
4-13-82	N	H	8	3.5													0	0
4-14-82	D	R	0	5.8													0	0
4-14-82	D	R	2	4.5													0	0
4-14-82	D	R	4	4.5													0	0
4-14-82	D	R	6	4.5													0	0
4-14-82	N	R	0	6.5													0	0
4-14-82	N	R	2	5.5													0	0
4-14-82	N	R	4	5.5													0	0
4-14-82	N	R	6	5.5													0	0

Appendix 6. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp. C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
4-14-82	D	W	0	3.2													0	0
4-14-82	D	W	8	3.5													0	0
4-14-82	D	W	14	3.5													0	0
4-14-82	D	W	20	3.5													0	0
4-13-82	N	W	0	2.0													0	0
4-13-82	N	W	8	1.9													0	0
4-13-82	N	W	14	1.9												UC: 34	34	0
4-13-82	N	W	20	1.5													0	0
5-11-82	D	C	0	12.7													0	0
5-11-82	D	C	2	12.0													0	0
5-11-82	D	C	4	12.0													0	0
5-11-82	D	C	6	11.5			34										34	0
5-11-82	N	C	0	12.5													0	0
5-11-82	N	C	2	12.3													0	0
5-11-82	N	C	4	12.3													0	0
5-11-82	N	C	6	12.0			45										45	47
5-11-82	D	D	0	15.0													0	0
5-11-82	D	D	2	14.4													0	0
5-11-82	D	D	4	14.4													0	0
5-11-82	D	D	6	14.4													0	0
5-11-82	D	D	8	14.2													0	0
5-11-82	N	D	0	12.0													0	0
5-11-82	N	D	2	11.0								37					37	0
5-11-82	N	D	4	11.0			56										56	0
5-11-82	N	D	6	11.0													0	0
5-11-82	N	D	8	10.8			318										318	0
5-11-82	D	E	0	12.8													0	0
5-11-82	D	E	8	8.2			25										25	0
5-11-82	D	E	14	8.2													0	0
5-11-82	D	E	20	6.5													0	0
5-10-82	N	E	0	12.0													0	0
5-10-82	N	E	8	11.0													0	0
5-10-82	N	E	14	11.0													0	0
5-10-82	N	E	20	7.3													0	0

Appendix 6. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
5-11-82	D	G	0	13.2													0	0
5-11-82	D	G	2	13.0													0	0
5-11-82	D	G	4	13.0													0	0
5-11-82	D	G	6	12.1													0	0
5-10-82	N	G	0	13.0													0	0
5-10-82	N	G	2	13.0													0	0
5-10-82	N	G	4	13.0													0	0
5-10-82	N	G	6	13.0													0	0
5-11-82	D	H	0	13.1													0	0
5-11-82	D	H	2	12.2													0	0
5-11-82	D	H	4	12.2													0	0
5-11-82	D	H	6	12.2			30										30	0
5-11-82	D	H	8	12.0	35												35	0
5-10-82	N	H	0	12.7													0	0
5-10-82	N	H	2	12.5													0	0
5-10-82	N	H	4	12.5													0	0
5-10-82	N	H	6	12.5													0	0
5-10-82	N	H	8	12.0													0	0
5-11-82	D	R	0	13.5	35												35	0
5-11-82	D	R	2	11.5			93										93	0
5-11-82	D	R	4	11.5			121										121	0
5-11-82	D	R	6	11.5			336										336	0
5-11-82	N	R	0	13.5	782												782	0
5-11-82	N	R	2	12.7			378										378	0
5-11-82	N	R	4	12.7			286										286	0
5-11-82	N	R	6	12.0			481										481	0
5-11-82	D	W	0	12.5													0	0
5-11-82	D	W	8	7.9								22					22	0
5-11-82	D	W	14	7.9								46					46	0
5-11-82	D	W	20	6.0								17					17	0
5-10-82	N	W	0	10.5													0	0
5-10-82	N	W	8	9.8													0	0
5-10-82	N	W	14	9.8													0	0
5-10-82	N	W	20	6.1													0	0

Appendix 6. Continued.

Sample Parameters					Species/Groups												
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-16-82	D	C	0	16.7	484	16		307								XP: 64	871	16
6-16-82	D	C	2	16.5	406			70									476	0
6-16-82	D	C	4	16.5	166			36									202	0
6-16-82	D	C	6	16.2	2951		42	21									3014	0
6-16-82	N	C	0	15.9	2866		81	502									3449	0
6-16-82	N	C	2	15.3	5387		312	37									5736	0
6-16-82	N	C	4	15.3	1054	19	155	19		39			19			XP: 39	1344	119
6-16-82	N	C	6	14.7	731	140	308			27			27				1233	0
6-16-82	D	D	0	19.0	1453			233									1686	0
6-16-82	D	D	2	16.5	452			56									508	0
6-16-82	D	D	4	16.5	484		18	37								XP: 55	594	0
6-16-82	D	D	6	16.5	1002			25									1027	0
6-16-82	D	D	8	12.0	92		46	46									184	0
6-16-82	N	D	0	18.0	4926	191	38	2119								XP: 95	7369	0
6-16-82	N	D	2	15.4	315		34	122					17			XP: 17	505	0
6-16-82	N	D	4	15.4	245		20	40									305	0
6-16-82	N	D	6	15.4	235		29									XP: 115 UC: 28	407	0
6-16-82	N	D	8	12.0	98		196	392									686	0
6-16-82	D	G	0	18.0	1198			175									1373	0
6-16-82	D	G	2	15.7	3465		32	379									3876	0
6-16-82	D	G	4	15.7	1367			21									1388	0
6-16-82	D	G	6	15.2	2032		52	79									2163	0
6-16-82	N	G	0	16.8	1375		17										1392	0
6-16-82	N	G	2	14.7	3769		19	154									3942	0
6-16-82	N	G	4	14.7	1107		57	57									1221	0
6-16-82	N	G	6	14.5	897	21	149	107									1174	0
6-16-82	D	H	0	17.2	239			213									452	0
6-16-82	D	H	2	16.0	578		17	119								XP: 84	798	0
6-16-82	D	H	4	16.0	211		84										295	0
6-16-82	D	H	6	16.0	228		51										279	0
6-16-82	D	H	8	12.0			62	62	58								182	0
6-16-82	N	H	0	16.0	307			146								XP: 40	493	0
6-16-82	N	H	2	15.0	583		172	57									812	0
6-16-82	N	H	4	15.0	149		110	75		18						XP: 37	389	0
6-16-82	N	H	6	15.0	40		240	120									400	0
6-16-82	N	H	8	12.5			63	189									252	0

Appendix 6. Continued.

Sample Parameters					Species/Groups												
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
6-16-82	D	R	0	16.7	2053			872									2925	0
6-16-82	D	R	2	16.5	1929			985								XP: 228	3142	0
6-16-82	D	R	4	16.5	1803			539									2342	0
6-16-82	D	R	6	14.5	661			43								XP: 14	718	0
6-16-82	N	R	0	16.8	922		18	1301								XP: 72	2313	0
6-16-82	N	R	2	16.2	2190		171	229		19							2609	19
6-16-82	N	R	4	16.2	394		34	68		17			17				530	120
6-17-82	N	R	6	14.8	305	20	60	20		20							425	20
7-20-82	D	C	0	25.5	418												418	0
7-20-82	D	C	2	24.5	436												436	0
7-20-82	D	C	4	24.5	38												38	0
7-20-82	D	C	6	23.0													0	0
7-20-82	N	C	0	23.5	389						32						421	0
7-20-82	N	C	2	22.0	1343						30					XP: 46	1419	15
7-20-82	N	C	4	22.0	364	27				13	27						431	572
7-20-82	N	C	6	22.0	152	30					15					XP: 15	212	0
7-20-82	D	D	0	26.0	76												76	31
7-20-82	D	D	2	24.0	188												188	0
7-20-82	D	D	4	24.0	63												63	0
7-20-82	D	D	6	24.0	72												72	0
7-20-82	D	D	8	22.5													0	0
7-20-82	N	D	0	24.0	248						31						279	15
7-20-82	N	D	2	22.5	692												692	0
7-20-82	N	D	4	22.5	771												771	0
7-20-82	N	D	6	22.5	133												133	0
7-20-82	N	D	8	20.0	40												40	0
7-20-82	D	G	0	25.0	167												167	0
7-20-82	D	G	2	24.5	126												126	0
7-20-82	D	G	4	24.5	25												25	0
7-20-82	D	G	6	23.0													0	0
7-20-82	N	G	0	24.5	2048	32											2080	0
7-20-82	N	G	2	23.0	1317	14	14										1345	0
7-20-82	N	G	4	23.0	767	19											786	0
7-20-82	N	G	6	22.0	1008												1008	0

Appendix 6. Continued.

Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
Sample Parameters					Species/Groups													
7-20-82	D	H	0	25.0	365												365	0
7-20-82	D	H	2	24.0	255												255	0
7-20-82	D	H	4	24.0													0	0
7-20-82	D	H	6	24.0													0	0
7-20-82	D	H	8	22.0													0	0
7-20-82	N	H	0	24.0	97											XP: 16	113	0
7-20-82	N	H	2	21.0	567												567	0
7-20-82	N	H	4	21.0	971												971	0
7-20-82	N	H	6	21.0	653												653	0
7-20-82	N	H	8	13.0	266												266	0
7-20-82	D	R	0	25.5	38												38	0
7-20-82	D	R	2	25.0	200												200	0
7-20-82	D	R	4	25.0	139												139	0
7-20-82	D	R	6	24.0													0	0
7-20-82	N	R	0	23.0	347												347	136
7-20-82	N	R	2	22.0	592					16						GS: 16	624	66
7-21-82	N	R	4	22.0	353	26											379	3631
7-21-82	N	R	6	22.0	90												90	4689
8-10-82	D	C	0	23.1	370												370	0
8-10-82	D	C	2	23.0	451												451	0
8-10-82	D	C	4	23.0	38												38	0
8-10-82	D	C	6	22.8	110												110	0
8-10-82	N	C	0	22.5	154	14											168	0
8-10-82	N	C	2	22.3	195			15									210	0
8-10-82	N	C	4	22.3	385												385	0
8-10-82	N	C	6	22.2	400												400	0
8-10-82	D	D	0	23.1	90												90	0
8-10-82	D	D	2	23.0	80												80	16
8-10-82	D	D	4	23.0													0	0
8-10-82	D	D	6	23.0													0	0
8-10-82	D	D	8	22.7	15												15	0
8-10-82	N	D	0	22.3	76												76	0
8-10-82	N	D	2	22.3	160												160	0
8-10-82	N	D	4	22.3	372		16										388	0
8-10-82	N	D	6	22.3	950		16										966	0
8-10-82	N	D	8	22.2	1039												1039	0

Appendix 6. Continued.

Sample Parameters					Species/Groups													
Date	Dl	Sta	Dpt	Temp C	AL	SP	SM	YP	TP	JD	CP	BR	SS	NS	FS	Misc.	Total Larvae	Eggs
8-10-82	D	G	0	23.0	112												112	0
8-10-82	D	G	2	22.9	137												137	0
8-10-82	D	G	4	22.9	45												45	0
8-10-82	D	G	6	22.7	19	18											37	0
8-10-82	N	G	0	22.0	192												192	0
8-10-82	N	G	2	21.5	165											XP: 15	180	0
8-10-82	N	G	4	21.5	239												239	0
8-10-82	N	G	6	21.5	679		16									XP: 16	711	0
8-10-82	D	H	0	22.9	168												168	0
8-10-82	D	H	2	22.8	85												85	0
8-10-82	D	H	4	22.8	51												51	0
8-10-82	D	H	6	22.8	72												72	0
8-10-82	D	H	8	22.5	60												60	0
8-10-82	N	H	0	22.8	465												465	0
8-10-82	N	H	2	22.8	1481											XP: 16	1497	0
8-10-82	N	H	4	22.8	677												677	0
8-10-82	N	H	6	22.8	484											XP: 17	501	0
8-10-82	N	H	8	22.7	352												352	0
8-10-82	D	R	0	23.0	68												68	0
8-10-82	D	R	2	23.0	86												86	0
8-10-82	D	R	4	23.0	152												152	0
8-10-82	D	R	6	23.0	60											XP: 15	75	0
8-10-82	N	R	0	22.1	170												170	0
8-10-82	N	R	2	22.1	446												446	0
8-10-82	N	R	4	22.1	395												395	0
8-10-82	N	R	6	22.0	387												387	0